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Research Article

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Selective Preoperative Nutrition-Related Testing and Adverse Outcomes After Primary Total Joint Arthroplasty: A Retrospective Cohort Study

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Abstract

Background: Preoperative nutritional vulnerability is a modifiable risk factor for adverse outcomes after total joint arthroplasty (TJA), but the utility of common nutrition-related biomarkers is unclear. This study evaluated associations between preoperative nutritional biomarkers, derived indices, and adverse postoperative outcomes after primary TJA.

Methods: This retrospective cohort study included 2,266 patients undergoing primary hip, knee, or shoulder arthroplasty at a single academic institution from June 2022 to June 2025. Albumin, total lymphocyte count (TLC), total protein (TP), Onodera Prognostic Nutritional Index (OPNI), and Geriatric Nutritional Risk Index (GNRI) were assessed when available within 30 days before surgery. The primary outcome was a study-defined composite adverse outcome consisting of a coded postoperative complication and/or revision related to the index arthroplasty. Biomarkers

were analyzed continuously and by risk category using adjusted logistic regression.

Results: Overall, 112/2,266 patients (4.94%) experienced the composite adverse outcome. Testing was infrequent: albumin was available in 268 patients, TLC in 494, TP in 243, OPNI in 136, and GNRI in 266. Low albumin was associated with a higher composite adverse outcome rate than normal albumin (16.39% vs 4.35%; p=.003) and remained independently associated with the composite outcome after adjustment (odds ratio [OR] 4.06, 95% confidence interval [CI] 1.51-10.89; p=.005). Higher albumin was protective when analyzed continuously (OR 0.17 per 1 g/dL; p<.001). Moderate GNRI risk remained independently associated with the composite outcome versus no risk (OR 10.29, 95% CI 2.08-50.81; p=.004). Higher continuous GNRI and OPNI were protective, whereas TLC and TP were not robustly associated with outcomes.

Conclusions: Among primary TJA patients with available testing, hypoalbuminemia was the most consistent nutrition-related marker associated with adverse outcomes. GNRI was associated with outcomes when evaluated separately but did not clearly outperform albumin. Testing was infrequent and likely selective, supporting prospective evaluation of standardized nutrition-focused risk assessment.

Keywords

total joint arthroplasty, malnutrition, albumin, Geriatric Nutritional Risk Index, Onodera Prognostic Nutritional Index, postoperative complications

Background

Primary total joint arthroplasty (TJA) volume continues to increase, with substantial projected growth in hip, knee, and shoulder arthroplasty demand and persistent concern regarding complications, revision surgery, and associated costs.[1-5] Preoperative nutritional vulnerability is a potentially modifiable risk factor in elective arthroplasty. In surgical and

orthopaedic populations, poorer nutritional status has been associated with postoperative morbidity, longer hospitalization, infection, and mortality.[6-10] However, nutrition-related risk assessment is not standardized in routine arthroplasty care, and it remains unclear which readily available laboratory measures are most informative for identifying patients at increased postoperative risk.

Albumin, total lymphocyte count (TLC), and total protein (TP) are commonly available laboratory measures that have been used as pragmatic markers of nutrition-related risk, although each is influenced by nonnutritional factors such as inflammation, systemic illness, immune status, and hydration.[11-18] Derived indices may provide broader risk stratification by combining multiple clinical variables. Onodera Prognostic Nutritional Index (OPNI), which incorporates albumin and TLC, has been associated with postoperative complications in orthopaedic and oncologic surgical settings.[19,20] The Geriatric Nutritional Risk Index (GNRI), which incorporates albumin and weight-based variables, has demonstrated prognostic utility in elderly medical and surgical populations and in revision total hip arthroplasty.[21-23] The relative performance of these biomarkers and indices in primary arthroplasty across the hip, knee, and shoulder remains insufficiently defined.

The objective of this study was to evaluate associations between commonly obtained preoperative nutrition-related biomarkers, derived nutritional indices, and adverse postoperative outcomes after primary TJA. We evaluated albumin, TLC, TP, OPNI, and GNRI because these measures are commonly available or derivable from routine preoperative laboratory data. We hypothesized that albumin-based measures, particularly albumin and GNRI, would show stronger associations with adverse outcomes than TLC or TP alone. We also characterized the

frequency and overlap of preoperative nutrition-related laboratory testing as a secondary assessment of current clinical practice.

Methods

Study Design and Cohort:

This retrospective cohort study included all primary total hip arthroplasty (THA), total knee arthroplasty (TKA), and total shoulder arthroplasty (TSA) procedures performed at the University of Arkansas for Medical Sciences (UAMS) from June 2022 through June 2025. For patients who underwent more than 1 primary arthroplasty during the study period, only 1 index procedure was included. Preoperative laboratory values were abstracted when performed within 30 days before the index procedure. Postoperative adverse events were attributed only to the index primary TJA. When more than 1 revision occurred, only the first revision was included.

During the study period, preoperative nutrition-related laboratory testing was not mandated by a standardized arthroplasty-specific protocol. Albumin, TLC, TP, and other laboratory values were obtained when indicated as part of clinical care when ordered by the treating surgeon, preoperative evaluation team, another clinician, or when available from recent preoperative testing. Therefore, laboratory availability was expected to reflect real-world selective testing rather than systematic screening of all primary TJA patients.

Outcomes:

The primary outcome was a study-defined broad composite postoperative adverse outcome, defined as any coded postoperative complication and/or revision related to the index primary arthroplasty. This composite was used because individual complication and revision events were infrequent. Because several composite components may not be directly nutrition-mediated, secondary and sensitivity outcomes included any coded postoperative complication,

revision alone, and infection-coded complication. Postoperative complications included instability/dislocation, fracture, infection, implant failure, and revision. Coded postoperative complications and revision were also analyzed separately in sensitivity analyses. Delayed wound healing, superficial dehiscence, and other wound-healing abnormalities were not reliably available as structured variables in the retrospective dataset and therefore could not be analyzed as discrete outcomes. Because infection-coded complications were uncommon, infection analyses were interpreted as exploratory and used primarily to assess biological plausibility.

Nutritional Biomarkers:

Nutritional biomarkers included serum albumin, TLC, and TP. Derived indices included OPNI and GNRI when sufficient component data were available. Albumin was categorized as low (<3.5 g/dL) or normal (>=3.5 g/dL).[12] TLC was categorized as low (<1,500 cells/mm^3) or normal (>=1,500 cells/mm^3).[14] TP was categorized as low (<6.0 g/dL), normal (6.0-8.3 g/dL), or high (>8.3 g/dL) according to laboratory reference categories.[16] OPNI was categorized as high risk (<40), moderate risk (40-45), and normal (>45).[20] GNRI was categorized as high risk (<82), moderate risk (82 to <92), low risk (92 to <=98), and no risk (>98).[21] The formulae necessary to calculate GNRI and OPNI are available in **Supplemental Figure 1**.

Data Analysis:

Descriptive statistics summarized cohort characteristics, outcome frequencies, arthroplasty type, complication subtypes, and laboratory availability. Baseline characteristics were compared between patients with and without the composite outcome using 2-sample t-tests for continuous variables and chi-square tests for categorical variables. Continuous biomarkers were compared by outcome status using Welch's t-test. Categorical biomarkers were compared using Fisher's exact tests because of sparse cell counts, and Cochran-Armitage trend tests

evaluated ordered risk strata for TP, OPNI, and GNRI. Logistic regression estimated odds ratios (ORs) and 95% confidence intervals (CIs) for each biomarker analyzed continuously and categorically. Adjusted models controlled for age, sex, body mass index (BMI), and arthroplasty type. Surgery year was evaluated descriptively but not included in final models because of limited event counts in biomarker subsets and concern for overfitting. Missingness and potential selection bias in laboratory testing was evaluated by comparing patients with versus without each available laboratory measure. Comparisons included age, BMI, sex, arthroplasty type, composite adverse outcome, coded postoperative complication, revision, and infection-coded complication. These analyses were intended to describe testing selectivity and were not interpreted as causal comparisons. All tests were 2-sided, and statistical significance was defined as $P<.05$. Analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

To characterize the extent to which nutrition-related tests were obtained in the same patients, laboratory overlap was summarized across albumin, TLC, TP, OPNI, and GNRI. We also tabulated mutually exclusive combinations of albumin, TLC, and TP availability because these component measures determine whether derived indices can be calculated. For each outcome, we compared a base model including age, sex, BMI, and arthroplasty type with models adding albumin, GNRI, or both albumin and GNRI. Model discrimination was summarized using the area under the receiver operating characteristic curve (AUC/c-statistic), and model fit was compared using Akaike information criterion (AIC) values. These analyses were considered exploratory because of limited event counts.

Results

A total of 2,266 primary TJAs were included: 1,022 THAs, 979 TKAs, and 264 TSAs. Overall, 112 patients (4.94%) experienced the composite postoperative adverse outcome,

including 87 patients (3.84%) with a coded postoperative complication and 66 patients (2.91%) who underwent revision; 41 patients experienced both event types. One patient had an arthroplasty type coded as other/unknown. This patient was included in the overall cohort sample size but excluded from arthroplasty type percentage calculations and the chi-square comparison of arthroplasty type. Coded postoperative complication rates did not differ significantly by arthroplasty type (p=.451), whereas revision (p=.003) and broad composite adverse outcome rates (p=.043) differed across THA, TKA, and TSA (**Table 1**). Infection was the most frequent coded complication overall, followed by pain, fracture, and implant failure.

Preoperative nutrition-related laboratory testing was infrequent. Albumin was available in 268 patients (11.8%), TLC in 494 (21.8%), TP in 243 (10.7%), OPNI in 136 (6.0%), and GNRI in 266 (11.7%) (**Figure 1**). Laboratory overlap was limited. Of the overall cohort, 1,640 patients (72.4%) had no albumin, TLC, or TP available; 358 (15.8%) had TLC only; 122 (5.4%) had albumin and TP only; 121 (5.3%) had albumin, TLC, and TP; 15 (0.7%) had albumin and TLC only; and 10 (0.4%) had albumin only. Among patients with albumin available, 243 also had TP, 136 also had TLC, 136 had OPNI, and 266 had GNRI (**Table 2**). Patients with the composite outcome were slightly younger than those without the outcome, whereas BMI and sex distribution did not differ (**Table 3**).

Analyses of laboratory availability suggested selective rather than random testing (**Table 4**). Comparisons of patients with and without available albumin, GNRI, and OPNI are shown in **Table 5**. Albumin and GNRI availability were numerically higher among patients with the broad composite outcome, although these differences did not reach statistical significance. OPNI availability showed stronger evidence of selection: the broad composite outcome occurred in 15 of 136 patients with OPNI available (11.0%) compared with 97 of 2,130 patients without OPNI

available (4.6%; p=.002) (**Table 4**). HbA1c was available in 336 patients (14.8%). HbA1c availability was numerically higher among patients with the broad composite outcome than among those without the composite outcome, but this difference was not statistically significant (19.6% vs 14.6%; p=.182). Patients with HbA1c testing had higher BMI than those without testing, further supporting clinically selective preoperative laboratory assessment.

Hypoalbuminemia was associated with higher rates of the broad composite adverse outcome, any coded postoperative complication, and infection-coded complication. Because infection-coded complications were uncommon, these results were interpreted as exploratory. The broad composite outcome occurred in 10 of 61 patients with low albumin (16.4%) compared with 9 of 207 patients with normal albumin (4.3%; p=.003) (**Figure 2**). Any coded complication occurred in 9 of 61 patients with low albumin (14.8%) compared with 7 of 207 patients with normal albumin (3.4%; p=.003). Infection-coded complication occurred in 4 of 61 patients with low albumin (6.6%) compared with 3 of 207 patients with normal albumin (1.4%; p=.049). Revision alone was not significantly associated with albumin category. TLC was not associated with the broad composite outcome, any coded complication, revision, or infection-coded complication. TP showed an ordinal trend across categories (p=.043), but categorical and continuous regression analyses were not significant, and estimates were limited by sparse cell counts in low and high TP categories (N=9, N=7).

OPNI category was not significantly associated with the composite adverse outcome, although event rates were numerically higher in worse risk strata. As a continuous variable, OPNI was lower among patients with the composite outcome and was associated with lower odds of the composite outcome in unadjusted regression (OR 0.91 per unit, 95% CI 0.85-0.98; p=.0178) (**Figure 3**). GNRI category was associated with the composite adverse outcome

(Fisher's exact p=.0019), with rates of 16.67% in the high-risk group, 28.57% in the moderate-risk group, 15.79% in the low-risk group, and 4.52% in the no-risk group (**Figure 2**). Event counts were small in the high-, moderate-, and low-risk groups. Infection-coded complication occurred in 1 of 12 high-risk GNRI patients (8.3%), 2 of 14 moderate-risk patients (14.3%), 1 of 19 low-risk patients (5.3%), and 3 of 221 no-risk patients (1.4%). Compared with the no-risk group, the moderate-risk group had higher unadjusted odds of the composite outcome (OR 8.44, 95% CI 2.25-31.65; p=.002). Higher continuous GNRI was associated with lower odds of the composite outcome (OR 0.96, 95% CI 0.93-0.99; p=.006). These findings support GNRI as a potential exploratory risk marker but require cautious interpretation.

In complete-case model comparisons among 266 patients with both albumin and GNRI available, albumin showed stronger discrimination than GNRI for the broad composite outcome and any coded complication. For the broad composite outcome, the base model including age, sex, BMI, and arthroplasty type had an AUC of 0.633. Adding albumin increased the AUC to 0.786, whereas adding GNRI increased the AUC to 0.740. Adding both albumin and GNRI yielded an AUC of 0.793. For any coded complication, the base model AUC was 0.642, compared with 0.798 for base plus albumin, 0.739 for base plus GNRI, and 0.806 for base plus both albumin and GNRI. For infection-coded complications, the base model AUC was 0.771, compared with 0.841 for base plus albumin, 0.750 for base plus GNRI, and 0.876 for base plus both albumin and GNRI (**Table 6**).

In models including both albumin and GNRI, albumin remained significantly associated with the broad composite outcome, any coded complication, and infection-coded complication, whereas GNRI was not independently associated with these outcomes. For the broad composite outcome, albumin was associated with lower odds (OR 0.04, 95% CI 0.01-0.31; p=.002),

whereas GNRI was not significant (OR 1.10, 95% CI 0.97-1.24; p=.138). Similar patterns were observed for any coded complication and infection-coded complication. These findings suggest that GNRI associations are partly driven by albumin and that GNRI did not clearly outperform albumin in this dataset.

Discussion

This retrospective cohort study found that preoperative nutrition-related laboratory testing before primary TJA was infrequent and selective in current TJA preoperative management. Among patients who underwent testing, hypoalbuminemia was the most consistent marker associated with broad adverse postoperative outcomes and infection-coded complications. GNRI was associated with adverse outcomes when evaluated separately; however, complete-case model comparisons did not show that GNRI clearly outperformed albumin, and GNRI was not independently significant when modeled together with albumin. These findings suggest that albumin remains the most practical and interpretable nutrition-related laboratory marker in this dataset, while GNRI should be considered hypothesis-generating rather than practice-changing. OPNI demonstrated a more limited association when analyzed continuously, whereas TLC and TP were not consistently informative.

Albumin was the clearest individual biomarker signal. Patients with hypoalbuminemia had a substantially higher rate of the composite adverse outcome than patients with normal albumin, and the association persisted in adjusted models. These findings are consistent with prior literature showing that albumin is associated with perioperative risk, while also recognizing that albumin is not specific to nutritional status and is influenced by inflammation, systemic illness, and physiologic reserve.[11-13] In elective arthroplasty, albumin may therefore be best

interpreted as a pragmatic marker of host vulnerability rather than a standalone diagnostic test for malnutrition.

GNRI was the most informative derived index when evaluated separately, but its added value beyond albumin was limited in complete-case model comparisons. Because GNRI incorporates albumin and weight-based variables, it may capture broader vulnerability than albumin alone while remaining feasible within routine clinical workflows. Prior studies have supported GNRI as a prognostic tool in elderly medical and surgical populations and in revision THA.[21-23] Our findings extend this concept to a primary arthroplasty cohort spanning hip, knee, and shoulder procedures. The higher risk observed in the moderate GNRI group should be interpreted cautiously because cell counts were small, but the consistency of categorical and continuous GNRI analyses supports further evaluation.

OPNI, TLC, and TP were less robust. OPNI was associated with outcomes when analyzed continuously but not categorically, suggesting that existing risk stratification thresholds may not be optimally calibrated for primary arthroplasty. TLC and TP did not provide consistent discrimination, likely reflecting the influence of immune, inflammatory, hydration, and other non-nutritional factors. These findings suggest that single laboratory values beyond albumin may have limited standalone value and that composite or multidomain risk assessment may be more informative.

The procedure-specific event table provides important context for interpreting the composite outcome (**Table 1**). Although coded complication rates were similar across THA, TKA, and TSA, revision and composite adverse outcome rates differed by arthroplasty type. This supports adjustment for arthroplasty type and highlights the importance of accounting for procedure-specific risk when evaluating perioperative nutritional vulnerability.

The primary limitation of this study is that preoperative nutrition-related laboratory testing was uncommon and likely nonrandom. Only a minority of patients had albumin, TP, TLC, GNRI, or OPNI data available, and laboratory availability varied across arthroplasty type and outcome groups. Therefore, these findings should not be interpreted as population-level prevalence estimates or causal biomarker effects across all arthroplasty patients. Instead, they identify a care gap and suggest that, among screened patients, hypoalbuminemia was the most consistent marker, while GNRI remains an exploratory derived index requiring prospective validation. Additional limitations include the single-center retrospective design, reliance on coding-based outcome ascertainment, residual confounding, small event counts in several biomarker subsets, and possible obscuring of joint-specific relationships by pooling hip, knee, and shoulder arthroplasty. Diabetes status was not included in the primary adjusted models because structured diabetes classification was not available uniformly across the full cohort; however, HbA1c testing patterns were examined descriptively as an additional indicator of selective preoperative laboratory assessment. The broad composite outcome should be interpreted cautiously because it included events that may not be directly nutrition-mediated, including instability, fracture, implant failure, pain, and revision. This limitation is important because malnutrition is most biologically plausible as a contributor to infection, wound healing, immune function, and impaired recovery. Because structured wound-healing and dehiscence variables were not available, we added infection-coded complication as the most nutrition-relevant coded sensitivity outcome available in the dataset. The persistence of an albumin signal for infection-coded complications strengthens the biologic plausibility of the findings, but sparse event counts preclude definitive conclusions.

Despite these limitations, this study reflects real-world clinical practice across a broad primary arthroplasty cohort and evaluates both individual biomarkers and derived nutritional indices using adjusted and sensitivity analyses. Prospective studies are needed to determine whether standardized preoperative assessment of albumin, GNRI, and broader multidomain nutritional and physiologic measures can improve risk stratification and guide optimization strategies before surgery.

Conclusions

Among primary TJA patients with available preoperative nutrition-related testing, hypoalbuminemia was the marker most consistently associated with composite postoperative adverse outcomes. GNRI was associated with the composite outcome when analyzed independently but did not clearly outperform albumin in complete-case model comparisons. Because testing was infrequent and likely selective, these findings should be interpreted as exploratory and hypothesis-generating. Prospective evaluation of standardized nutrition-focused risk assessment and optimization pathways before arthroplasty is warranted.

List of Abbreviations

- AIC – Akaike information criterion
- ALB – Albumin
- AUC – Area under the receiver operating characteristic curve
- BMI – Body mass index
- CI – Confidence interval
- GNRI – Geriatric Nutritional Risk Index
- HbA1c – Hemoglobin A1c
- IRB – Institutional Review Board

- OPNI – Onodera Prognostic Nutritional Index
- OR – Odds ratio
- THA – Total hip arthroplasty
- TJA – Total joint arthroplasty
- TKA – Total knee arthroplasty
- TLC – Total lymphocyte count
- TP – Total protein
- TSA – Total shoulder arthroplasty
- UAMS – University of Arkansas for Medical Sciences

Declarations

Ethics approval and consent to participate: This retrospective cohort study was reviewed and approved by the University of Arkansas for Medical Sciences Institutional Review Board (IRB No. 298965). The requirement for informed consent was waived because the study involved retrospective review of deidentified clinical data and posed minimal risk to participants. All study procedures were conducted in accordance with institutional requirements and applicable ethical standards. This study was conducted in accordance with the principles laid out in the Declaration of Helsinki.

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Figures and tables:

Table 1. Broad postoperative adverse events by index arthroplasty type

Event	THA N=1,022	TKA N=979	TSA N=264	Total N=2,266	*p* value
Coded postoperative complication	45 (4.4)	33 (3.4)	9 (3.4)	87 (3.8)	.451
Revision	33 (3.2)	18 (1.8)	15 (5.7)	66 (2.9)	*.003
Composite postoperative adverse	56 (5.5)	37 (3.8)	19 (7.2)	112 (4.9)	*.043

Coded complication type	THA N=1,022	TKA N=979	TSA N=264	Total N=2,266
Infection	12 (1.2)	12 (1.2)	4 (1.5)	28 (1.2)
Pain	6 (0.6)	10 (1.0)	0 (0.0)	16 (0.7)
Fracture	10 (1.0)	1 (0.1)	2 (0.8)	13 (0.6)
Failure	7 (0.7)	2 (0.2)	1 (0.4)	10 (0.4)
Dislocation	5 (0.5)	0 (0.0)	0 (0.0)	5 (0.2)
Instability	2 (0.2)	1 (0.1)	2 (0.8)	5 (0.2)
Stiffness	0 (0.0)	5 (0.5)	0 (0.0)	5 (0.2)
Recall	2 (0.2)	1 (0.1)	0 (0.0)	3 (0.1)
Other	1 (0.1)	1 (0.1)	0 (0.0)	2 (0.1)

Footnote: * Indicates statistical significance at $p<.05$. Values are presented as n (%). Percentages are calculated within each index arthroplasty group. Coded postoperative complications were identified from diagnosis/procedure coding and categorized by recorded complication type. The composite postoperative adverse outcome was defined as a coded postoperative complication and/or revision related to the index primary arthroplasty. *P* values compare event frequency

across THA, TKA, and TSA groups using chi-square tests. THA = total hip arthroplasty; TKA = total knee arthroplasty; TSA = total shoulder arthroplasty.

Table 2. Laboratory overlap matrix

Lab	N	%	ALB (N)	TLC (N)	TP (N)	OPNI (N)	GNRI (N)
Albumin	268	11.8	268	136	243	136	266
TLC	494	21.8	136	494	121	136	134
TP	243	10.7	243	121	243	121	241
OPNI	136	6.0	136	136	121	136	134
GNRI	266	11.7	266	134	241	134	266

Footnote: Values represent the number of patients with available overlapping laboratory results. Available % is calculated using the full cohort denominator (N=2,266). ALB = albumin; TLC = total lymphocyte count; TP = total protein; OPNI = Onodera's Prognostic Nutritional Index; GNRI = Geriatric Nutritional Risk Index.

Table 3. Baseline characteristics by composite postoperative adverse outcomes

Characteristic	Overall N=2,266	No Composite Outcome N=2,154	Composite Outcome N=112	*p* value
Age, y	66.3 ± 12.2	66.4 ± 12.2	63.8 ± 13.2	*.047
Women, n (%)	1,288 (56.8)	1,227 (57.0)	61 (54.5)	.672
BMI, kg/m²	30.4 ± 6.0	30.4 ± 6.0	30.7 ± 6.5	.660
Arthroplasty type, n (%)				*.043
THA	1,022 (45.1)	966 (44.9)	56 (50.0)	
TKA	979 (43.2)	942 (43.7)	37 (33.0)	
TSA	264 (11.7)	245 (11.4)	19 (17.0)	
Surgery year, n (%)				*.018
2022	376 (16.6)	366 (17.0)	10 (8.9)	
2023	773 (34.1)	719 (33.4)	54 (48.2)	
2024	785 (34.6)	756 (35.1)	29 (25.9)	

2025	332 (14.7)	313 (14.5)	19 (17.0)

Footnote: *Indicates statistical significance at $p<.05$. Values are presented as mean ± standard deviation or n (%), as appropriate. Composite outcome was defined as a coded postoperative complication and/or revision related to the index primary arthroplasty. Continuous variables were compared using 2-sample t-tests, and categorical variables were compared using chi-square tests. BMI = body mass index; THA = total hip arthroplasty; TJA = total joint arthroplasty; TKA = total knee arthroplasty; TSA = total shoulder arthroplasty.

Table 4. Laboratory testing availability among those with and without composite adverse events

Laboratory Measure	Available, n (%)	Not available, n (%)	Available among no composite outcome, n/N (%)	Available among composite outcome, n/N (%)	*p* value
Albumin	268 (11.8)	1,998 (88.2)	249/2,154 (11.6)	19/112 (17.0)	.115
TLC	494 (21.8)	1,772 (78.2)	465/2,154 (21.6)	29/112 (25.9)	.338
TP	243 (10.7)	2,023 (89.3)	229/2,154 (10.6)	14/112 (12.5)	.641
OPNI	136 (6.0)	2,130 (94.0)	121/2,154 (5.6)	15/112 (13.4)	*.002
GNRI	266 (11.7)	2,000 (88.3)	247/2,154 (11.5)	19/112 (17.0)	.107
HbA1c	336 (14.8)	1,930 (85.2)	314/2,154 (14.6)	22/112 (19.6)	.182

Footnote: *Indicates statistical significance at p<.05. Values are presented as mean ± standard deviation or n (%), as appropriate (N=2,266). Laboratory availability was defined as measurement within 30 days before the index primary arthroplasty. Composite outcome was defined as a coded postoperative complication and/or revision related to the index primary arthroplasty. Continuous variables were compared using 2-sample t-tests, and categorical variables were compared using chi-square tests. GNRI = Geriatric Nutritional Risk Index; OPNI = Onodera Prognostic Nutritional Index; TLC = total lymphocyte count; TP = total protein.

Table 5. Characteristics of patients with and without available albumin, GNRI, and OPNI data

Characteristic	Albumin available n=268	Albumin not available n=1,998	*p* value	GNRI available n=266	GNRI not available n=2,000	*p* value	OPNI available n=136	OPNI not available n=2,130	*p* value
Age, y	66.1 ± 12.8	66.3 ± 12.2	.775	66.0 ± 12.8	66.3 ± 12.2	.717	65.6 ± 12.4	66.3 ± 12.2	.542
BMI, kg/m²	29.9 ± 5.7	30.5 ± 6.0	.110	29.9 ± 5.7	30.5 ± 6.0	.110	29.9 ± 5.4	30.5 ± 6.0	.292
Women, n (%)	162 (60.4)	1,126 (56.4)	.084	159 (59.8)	1,129 (56.5)	.105	82 (60.3)	1,206 (56.6)	.268
TJA type, n (%)			.093			.095			.206
THA	140 (52.2)	882 (44.1)		139 (52.3)	883 (44.1)		73 (53.7)	949 (44.6)	
TKA	102 (38.1)	877 (43.6)		101 (38.0)	878 (43.9)		48 (35.3)	931 (43.7)	
TSA	26 (9.7)	238 (11.9)		26 (9.8)	238 (11.9)		15 (11.0)	249 (11.7)	
Composite adverse outcome, n (%)	19 (7.1)	93 (4.7)	.115	19 (7.1)	93 (4.7)	.107	15 (11.0)	97 (4.6)	*.002

Footnote: *Indicates statistical significance at p<.05. Values are presented as mean ± standard deviation or n (%), as appropriate (N=2,266). Laboratory availability was defined as measurement within 30 days before the index primary arthroplasty. Composite outcome was defined as a coded postoperative complication and/or revision related to the index primary arthroplasty. Continuous variables were compared using 2-sample t-tests, and categorical variables were compared using chi-square tests. BMI = body mass index; GNRI = Geriatric Nutritional Risk Index; OPNI = Onodera Prognostic Nutritional Index; THA = total hip arthroplasty; TKA = total knee arthroplasty; TSA = total shoulder arthroplasty.

Table 6. Model comparison for albumin vs GNRI

Outcome	Model	N	Events	AUC / c-statistic	AIC
Composite	Base	266	19	0.633	144.9
Composite	Base + albumin	266	19	0.786	129.3
Composite	Base + GNRI	266	19	0.740	140.6
Composite	Base + albumin + GNRI	266	19	0.793	126.1
Any coded complication	Base	266	16	0.642	128.6
Any coded complication	Base + albumin	266	16	0.798	112.9
Any coded complication	Base + GNRI	266	16	0.739	124.9
Any coded complication	Base + albumin + GNRI	266	16	0.806	109.4
Infection-coded complication	Base	266	7	0.771	70.6
Infection-coded complication	Base + albumin	266	7	0.841	64.4
Infection-coded complication	Base + GNRI	266	7	0.750	72.5
Infection-coded complication	Base + albumin + GNRI	266	7	0.876	58.7

Footnote: Logistic regression models were compared for prediction of the composite postoperative adverse outcome, any coded postoperative complication, and infection-coded complications. The base model included age, sex, BMI, and arthroplasty type. Albumin and GNRI were entered as continuous variables. All models were evaluated using the same complete case sample. Higher AUC/c-statistic values indicate better discrimination, whereas lower AIC values indicate better relative model fit. AIC = Akaike information criterion; AUC = area under the receiver operating characteristic curve; BMI = body mass index; GNRI = Geriatric Nutritional Risk Index.

Figure Legends:

Figure 1. Cohort flow and preoperative nutrition-related laboratory availability. Flow diagram showing cohort inclusion, composite postoperative adverse outcome frequency, and availability of preoperative nutrition-related laboratory data within 30 days before index primary

arthroplasty. GNRI = Geriatric Nutritional Risk Index; OPNI = Onodera Prognostic Nutritional Index; THA = total hip arthroplasty; TKA = total knee arthroplasty; TLC = total lymphocyte count; TSA = total shoulder arthroplasty.

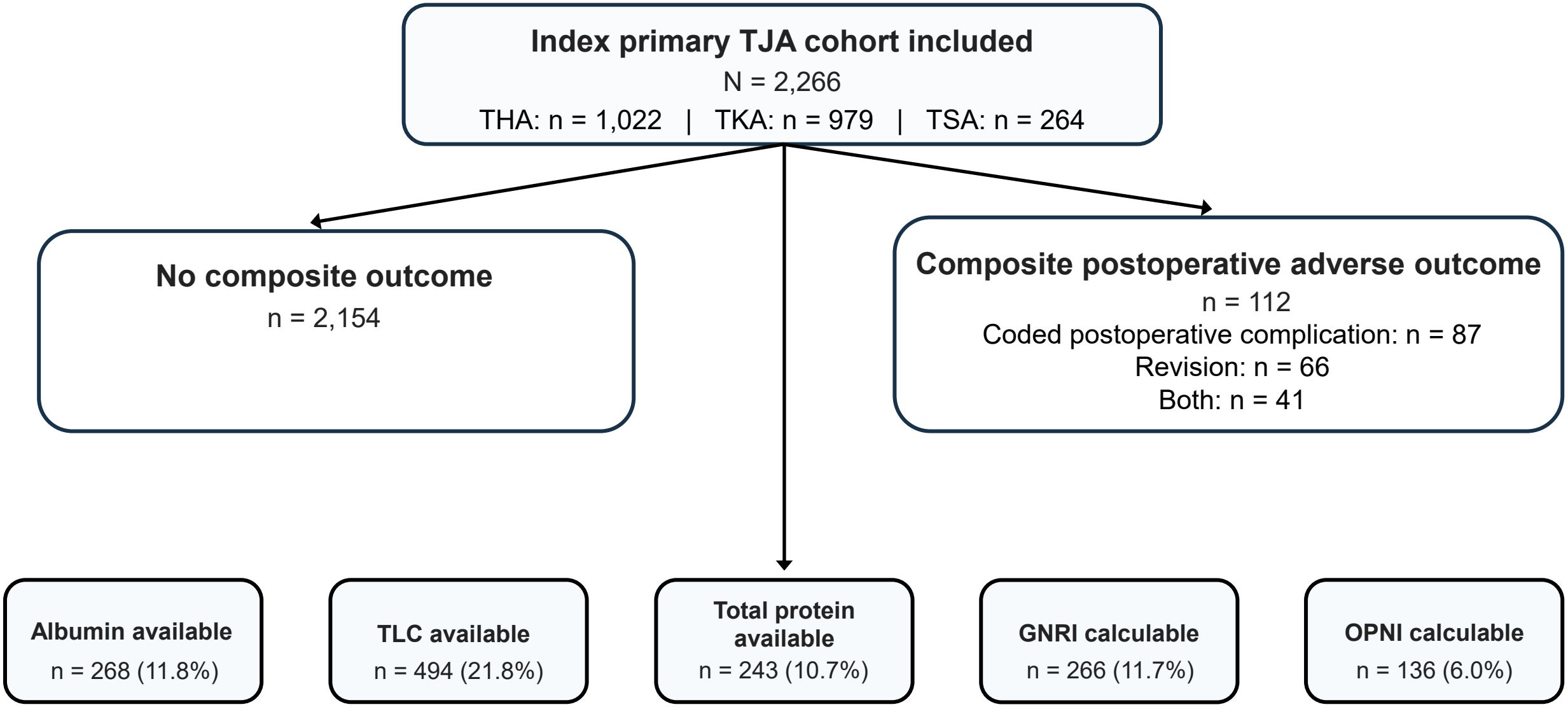
Figure 2. Unadjusted Composite Postoperative Adverse Outcome Rates by Nutritional Risk Category. Bars show the percentage of patients with a coded postoperative complication and/or revision related to the index primary arthroplasty. Error bars represent Wilson 95% confidence intervals. Within-bar labels indicate event counts over total category counts. *P* values represent omnibus group comparisons, with an additional Cochran-Armitage trend test shown for ordered GNRI categories. GNRI = Geriatric Nutritional Risk Index; OPNI = Onodera Prognostic Nutritional Index.

Figure 3. Adjusted Associations Between Nutritional Predictors and Composite Postoperative Adverse Outcomes. Forest plot showing adjusted odds ratios and 95% confidence intervals for preoperative nutritional predictors of the composite postoperative adverse outcome. The composite outcome was defined as a coded postoperative complication and/or revision related to the index primary arthroplasty. Models were adjusted for age, sex, body mass index, and arthroplasty type. The vertical reference line indicates an odds ratio of 1.0. GNRI = Geriatric Nutritional Risk Index; OPNI = Onodera Prognostic Nutritional Index; OR = odds ratio.

Supplemental Figure Legend:

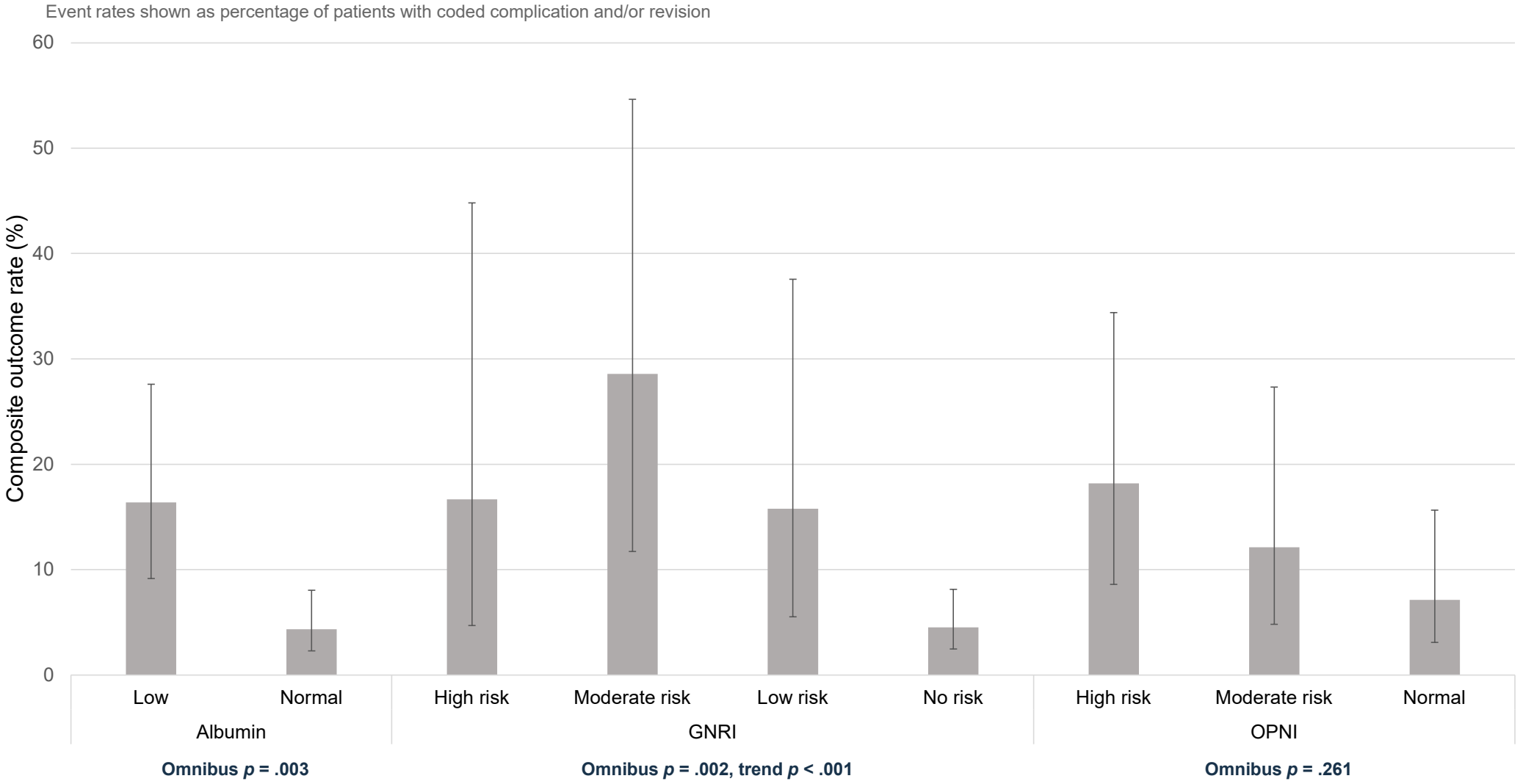
Supplemental Figure 1. GNRI and OPNI formulae. Graphic display of the equations necessary to calculate GNRI and OPNI. GNRI = Geriatric Nutritional Risk Index, OPNI = Onodera's Prognostic Nutritional Index.

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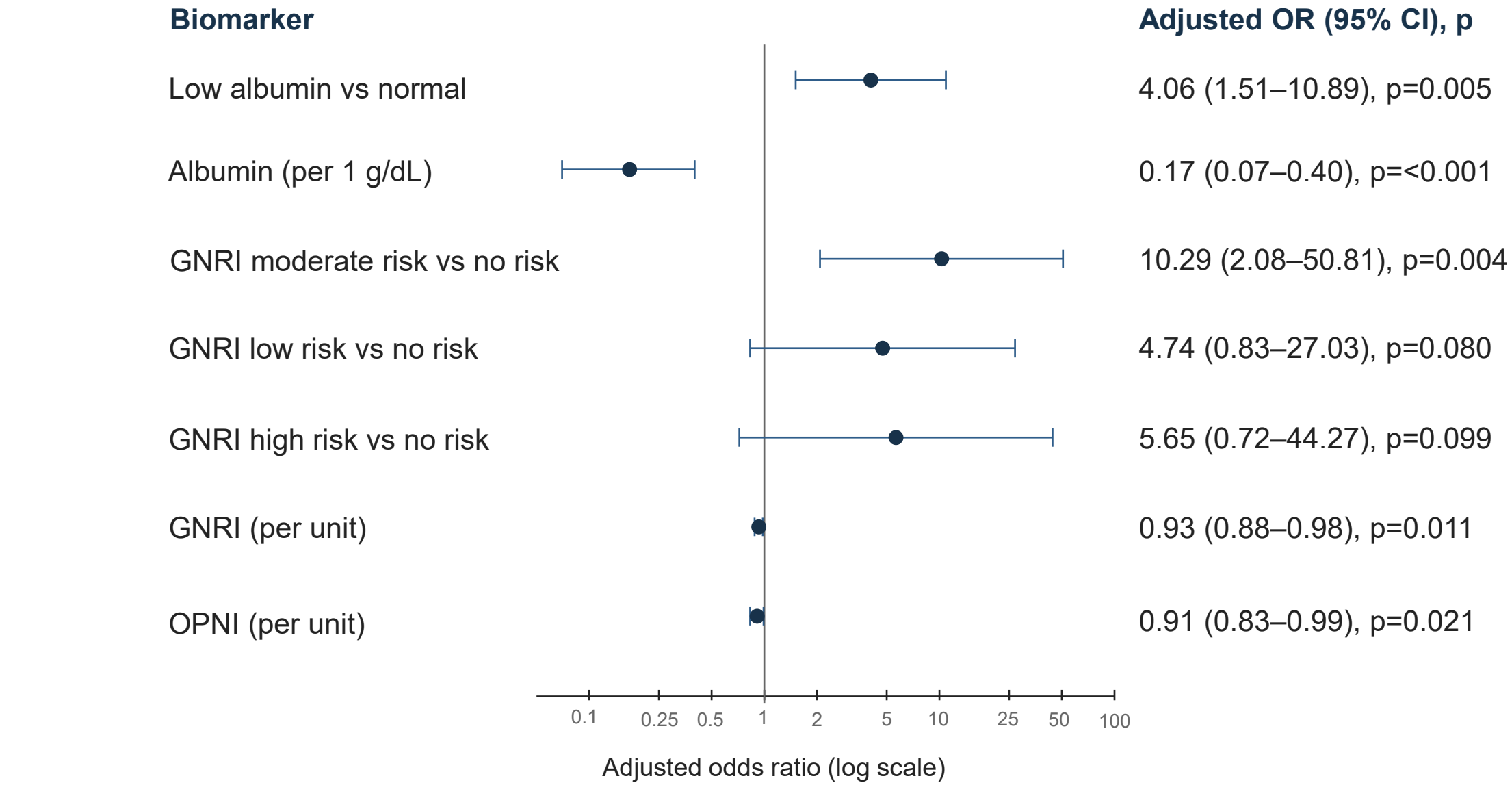
Preoperative nutrition-related laboratory availability within 30 days before surgery

Abbreviations: GNRI, Geriatric Nutritional Risk Index; OPNI, Onodera's Prognostic Nutritional Index; THA, total hip arthroplasty; TKA, total knee arthroplasty; TLC, total lymphocyte count; TSA, total shoulder arthroplasty.



Bars represent the proportion of patients in each category who experienced the composite postoperative adverse outcome.

Adjusted odds ratios from models controlling for age, sex, BMI, and arthroplasty type



Composite outcome defined as coded postoperative complication and/or revision related to the index primary arthroplasty.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementalFigure1FullRes.pdf