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REVIEW

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Malnutrition in spondylodiscitis: an overlooked risk factor

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Abstract

Objective Spondylodiscitis presents a significant diagnostic and treatment challenge to healthcare providers, with various risk factors and treatment outcomes having been identified. Malnutrition, a multifactorial condition defined by imbalance or deficiency of nutrients, is a known risk factor for various adverse events such as postoperative infection and readmissions in spine surgery. However, its impact in SD has not yet been explored. The study aims to assess the prevalence of malnutrition and hypoalbuminemia in SD patients and their impact on the 90-day-all-cause readmission and in-hospital mortality rates.

Methods Using the 2020 Nationwide Readmission Database, adult patients were selected by primary ICD-10 diagnosis for SD (M46.2x, M46.3x and M46.4x). Demographic information and clinical data were extracted. Readmissions were identified by *VisitLink*. Patients were categorized into 2 groups: those with malnutrition and/or hypoalbuminemia and those without. Descriptive and comparative analysis, with multivariate regression models to assess for independent risk factors of mortality and readmission were performed.

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Conclusion Malnutrition and hypoalbuminemia are relatively common in SD patients and are significant risk factors for both in-hospital mortality and readmission. Early identification, including screening for hypoalbuminemia and management of malnutrition, may be beneficial in SD treatment.

Keywords Big data, Large database, Bibliometric analysis, Spine, Spine surgery, Research

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Introduction

The number of patients suffering from spondylodiscitis (SD) is rising globally [1–3]. Due to its insidious onset and ambiguous presentation, SD continues to present a significant challenge to healthcare providers. Overall, mortality remains high, up to 7.3%, despite improvements in diagnostics and treatments [4]. Various studies, including large database analyses, have identified a multitude of risk factors for SD and its treatment outcomes. Typically reported risk factors include advanced age, morbid obesity, diabetes mellitus, long-term systemic steroid use, cirrhosis of the liver, hemodialysis dependency, intravenous drug use and malignancy [5–8].

Malnutrition is a multifactorial condition widely defined by imbalance or deficiency of essential life and vitality supporting nutrients, resulting from inadequate diet, poor nutrition or environmental causes [9]. Although the term describes over- and under-nourishment, it usually represents undernutrition associated with muscle wasting and sarcopenia. Malnutrition has previously been identified as a major risk factor for adverse events in spine surgery. Malnourished patients have an increased risk for postoperative complications, including surgical site infections, sepsis, renal and cardiac complications. Additionally, odds of readmission and one-year mortality are greater [10–15].

Unfortunately, there is not a single marker that defines malnutrition.

Serological makers for malnutrition such as albumin, pre-albumin, transferrin, and total lymphocyte count may be used for screening, but are challenging to implement due to cost and time delay factors [16, 17]. Albumin, as a more cost-effective and rapid marker, has been the focus of numerous studies. Hypoalbuminemia has shown similar associations with adverse outcomes as the broader entity of malnourishment [10, 11, 18].

Studies of the effects of malnutrition in those with SD are rare. A single study demonstrated that hypoalbuminemia was a risk factor for major adverse events, wound complications and 30-days readmission [18].

The aim of this study was to assess the prevalence of malnutrition and hypoalbuminemia in SD patients and their impact on the 90-day-all-cause readmission and in-hospital mortality rates.

Methods

Study design and data source

This was a retrospective cohort study utilizing data from the 2020 Nationwide Readmission Database (NRD) by the Healthcare Cost and Utilization Project (HCUP). Demographic and clinical data, including admission and readmission details such as elective admission, as well as length of stay (LOS), medical comorbidities, and in-hospital death were extracted. All comorbidities present at discharge were identified by ICD-10 codes and primary clinical classifications software refined (CCSR) for International Classification of Diseases (ICD)-10 category codes, Version 2023.1. The Elixhauser Comorbidity Indexes for in-hospital mortality and all-cause 30-day readmission risks were calculated for each patient. As per the HCUP data use agreement, variables were excluded from tabulation if there were 10 or fewer patients possessing the factor.

Population

Adult patients (≥18 years old) were screened for spondylodiscitis as their primary diagnosis using the International Classification of Diseases (ICD)-10 codes, Version 2023.1, (M46.2x, M46.3x and M46.4x). Patients were excluded if they had a diagnosis of malignancy, traumatic injury, or an admission within the first 9 months of the year 2020.

Study cohorts.

The study cohorts were categorized into 2 groups based on presence of malnutrition and/or hypoalbuminemia, Malnutrition was defined using the CCSR code END008, while hypoalbuminemia was classified by the ICD-10 codes E88.09 and R77.0.

Patients without malnutrition or hypoalbuminemia served as the control group.

Outcomes

All cause readmissions were identified by NRD *Visit-Links*. Only patients admitted within the first 9 months of the year 2020 were included, to reliably calculate the 90-day-all-cause readmission-rates. The time until readmission was measured as the number of days between a patient's discharge and their subsequent admission to the hospital.

In-hospital mortality was defined as the death of a patient during their initial hospital stay.

Statistical analysis

We initially sought to determine if malnutrition and hypoalbuminemia had a differential effect on the outcomes. If none was found, we planned to combine them into a single malnutrition variable which included malnutrition, hypalbuminemia, or both diagnoses. For descriptive statistics, means were presented with standard deviations (SD) and frequency counts with percentages by the exposure. These comparisons were made using Chi-square tests for categorical variables and independent student t-tests for continuous variables. A multivariable logistic regression was performed to evaluate the effect of malnutrition and/or hypoalbuminemia on readmission and in-hospital mortality. The following potential confounding variables were selected by clinical expert opinion and previously published literature: age,

Table 1 Demographics of the study population and comorbidities

	Control cohort *N* = 4898	Malnutrition *N* = 833	*p*-value
Patient demographics		***N*(%) or**	
Age	59.8 (15.8)	63.74 (15.6)	< 0.001
Male	2966 (60.6)	483 (58)	0.161
Elixhauser in-hospital mortality index	-1.65 (8.3)	-0.17 (9.3)	< 0.001
Elixhauser 30 days readmission index	4.92 (5.3)	5.65 (5.6)	< 0.001
Admission details			
Elective Admission	355 (6.2)	40 (4.8)	0.071
Length of stay	11.7 (14.17)	16.9 (22)	< 0.001
Comorbidities			
Obesity	918 (16)	110 (13.2)	0.017
Diabetes mellitus type 2	1668 (29.1)	236 (28.3)	0.595
Hypertension	3598 (62.8)	535 (64.2)	0.351
Depression	839 (14.6)	115 (13.8)	0.461
Autoimmune disease	248 (4.3)	38 (4.6)	0.719
Chronic lung disease	1041 (18.2)	159 (19.1)	0.455
Thyroid disease	911 (15.9)	164 (19.7)	< 0.001
Heart failure	777 (13.6)	148 (17.8)	< 0.001
Renal failure	390 (6.8)	66 (7.9)	0.166

sex, obesity, diabetes, hypertension, depression, autoimmune, chronic lung, thyroid disease, heart, renal, and liver failure. Potential covariables were evaluated for high levels of co-linearity. The effect of malnutrition and each additional risk factor, controlling for the others in the model, were reported using adjusted odds ratios (aOR) along with 95% confidence intervals (CI) and p-values. We included all potential confounders in the model to get the most precise estimate of effect; however, we only included those that were statistically significant in the regression results tables. The level of statistical significance was set at $p=0.05$. All analyses were performed using Stata software, version 15.0 (College Station, Texas, USA).

Results

Patient population

In total 5,731 patients met our inclusion criteria. The prevalence of malnutrition and hypoalbuminemia in those with SD was 13% ($n=767$) and 1.7% ($n=96$), respectively. In addition to that, 30 patients had both malnutrition and hypoalbuminemia.

The risks for readmission in those with malnutrition in combination with hypoalbuminemia were 40% ($n=309$) and 41% ($n=39$), respectively. The risks for in-hospital mortality in those with malnutrition and hypoalbuminemia were 3% ($n=19$) and 4% ($n=4$), respectively. Since the risks for both outcomes were similar, and the prevalence of hypoalbuminemia was so low, we combined them into a single malnutrition variable ($n=833$; 14.5%).

Table 2 Outcomes

	Control cohort *N* = 4898	Malnutrition *N* = 833	*p*-value
Readmission	1653 (33.7)	334 (40.1)	< 0.001
Time to first readmission (days)	35 (23)	40.7 (23.2)	< 0.001
Number of readmissions	1.43 (0.8)	1.39 (0.7)	0.3617
In-hospital death	61 (1.1)	21(2.5)	< 0.001

We found several significant differences between the study cohorts (Table 1).

Malnourished patients were significantly older (63.74 years to 59.8; p=<0.001) with a comparable gender distribution. Elective admission status was scarce in both groups, with malnutrition having a longer LOS (16.9 days to 11.7; <0.001).

The Elixhauser Indices, indicating the comorbidity burden, were higher for both in-hospital mortality (Malnutrition -0.17 ± 9.3 vs. Control -1.65 ± 8.3, $p<0.001$) and 30-day readmission (Malnutrition 5.65 ± 5.6 vs. Control 4.92 ± 5.3, $p<0.001$). This indicates a greater risk for both mortality and readmission in the malnutrition group.

Among the comorbidities, malnutrition had a significantly higher prevalence of thyroid disease (19.7% vs. 15.9%) and heart failure (17.8% vs. 13.6%). No significant differences were observed in the rates of type 2 diabetes mellitus, hypertension, depression, autoimmune disease, chronic lung disease, or renal failure between the two cohorts. Obesity was significantly more frequent in the control group (16% vs. 13.2%).

Outcomes

The malnutrition group had a significantly higher readmission rate (40.1%) compared to the control group (33.7%; $p<0.001$), Table 2. Despite these differences, the number of readmissions did not differ significantly between the groups, with both cohorts having around 1.4 readmissions (1.39 ± 0.7 in the malnutrition group vs. 1.43 ± 0.8 in the control group, $p=0.3617$).

Multivariable logistic regression estimating the effects on readmission

Our analysis revealed several risk factors significantly influencing the risk of readmission (Table 3). Malnutrition was associated with a 25% increase in readmission risk (aOR 1.25, 95% CI 1.07–1.47, $p=0.006$), with Elective Admission also having increased odds. The strongest risk factor of readmission was thyroid disease (aOR 3.48, 95% CI 2.99–4.05, $p<0.001$).

Table 3 Multivariate logistic regression analyses estimating the effects on readmission

Factor*	aOR**	95% CI**	*p*-value
Malnutrition	1.25	1.07–1.47	0.006
Age	0.99	0.98–0.99	< 0.001
Elective Admission	1.11	0.98–1.25	< 0.001
Obesity	0.85	0.72–1.00	< 0.045
Hypertension	1.27	1.11–1.45	< 0.001
Thyroid disease	3.48	2.99–4.05	< 0.001
Heart failure	1.87	1.57–2.22	< 0.001
Renal failure	1.78	1.42–2.23	< 0.001

*The regression model included all risk factors in Table 1 but only those that were statistically significant were reported in the table

**adjusted odds ratio and 95% confidence interval

Table 4 Multivariate logistic regression analyses estimating on in-hospital mortality

Factor	aOR*	95% CI*	*p*-value
Malnutrition	2.57	1.49–4.44	0.001
Age	1.07	1.05–1.09	< 0.001
Elective Admission	3.46	1.65–7.26	0.001
Diabetes mellitus type 2	1.82	1.06–3.14	0.031
Renal failure	2.94	1.44–5.99	0.003

*The regression model included all risk factors in Table 1 but only those that were statistically significant were reported in the table

**adjusted odds ratio and 95% confidence interval

Interestingly, age and obesity showed a protective effect, with a slight decrease in readmission risk.

Multivariable logistic regression estimating the effects on in-hospital mortality

Various factors were significantly associated with the risk of in-hospital mortality (Table 4).

Malnutrition was found to more than double the risk of mortality (aOR 2.57, 95% CI 1.49–4.44, $p=0.001$). Type 2 diabetes and renal failure also showed increased odds. The strongest predictor of in-hospital mortality, however, was elective admission status (aOR 3.46, 95% CI 1.65–7.26, $p=0.001$).

Discussion

Management of SD remains challenging with a high mortality and globally increasing incidence. Identifying risk factors may help healthcare providers in optimizing evidence-based treatment algorithms, reducing the burden on healthcare systems.

Malnutrition has been shown to be a key component of immunodeficiency, with subsequent increased susceptibility towards infections [19–21]. This may be particularly relevant in patients with SD, with infection being the causative pathology. Our study showed that a high number of SD patients suffered from malnutrition or hypoalbuminemia (14.5%). Elsamadicy et al. found a rate of malnutrition of 4.5% in a degenerative spondylolisthesis cohort [12]. Compared to that cohort our study had an almost triple incidence of malnutrition. This underscores the role of malnutrition in development of infections.

Malnutrition is a known risk factor for adverse outcomes in elective spine surgery with association towards postoperative complications, including surgical site infections, sepsis, renal, cardiac complications [8–10, 14]. In addition to that, significantly higher rates of readmissions and a prolonged LOS was found for malnourished patients [12]. Our results align with existing publications. Malnutrition was associated with significantly higher odds of readmission (1.25) and in-hospital mortality (2.57) and a higher LOS (16.9 days ± 22). Compared to the study by.

Elsamadicy et al. we again had an almost triple values for rate of readmission and (14.5%, 40.1%) and LOS (4.51 days vs. 16.9). These findings not only underscore the severity of SD itself but the impact and burden of malnutrition on the healthcare system.

However, the specific impact on SD has only been studied by Camino-Willhuber et al. [18]. In this smaller study, they showed higher risk for readmission and mortality in patients with hypoalbuminemia. Our study confirms these results and underscores the essential role of malnourishment in managing systematic diseases like SD. Clearly, malnutrition in our study showed a higher rate of readmission and mortality.

In our cohort, the incidence of hypoalbuminemia was small (1.7%), with its clinical impact noted but unclear in its predictiveness of malnutrition. Studies showed that hypoalbuminemia is linked to various adverse outcomes in spine surgery, including mortality [11, 12, 14, 18]. Assessing for hypoalbuminemia, reflecting chronic undernutrition and low protein intake, may be beneficial in the treatment of SD. While hypoalbuminemia may be associated with malnutrition, it doesn't define the condition, and its role as a diagnostic indicator remains uncertain. Nutritional support programs and assessments such as the Enhanced Recovery After Surgery (ERAS) concept are already used by other surgical specialties. These have shown reduce adverse effects [22–26].

Medical comorbidities have been identified as risk factors for both readmission and in-hospital mortality in our study. Among various others, these are already well-established risk factors in spine surgery and in treatment of SD [4, 6, 7, 27, 28]. These findings underscore the value of a multi-disciplinary treatment approach. To our surprise, both age and obesity were predictive odds for readmission. We cannot elucidate this puzzling finding as both factors are well known to be associated with increased readmission rates in spine surgery [5, 29, 30].

Elective admission status was the greatest risk factor for mortality. This underscores the need for timely diagnosis and initiation of a targeted treatment.

Limitation

While providing valuable insights into the relationship between malnutrition and spondylodiscitis, our study has several inherent limitations primarily related to the nature of the utilized dataset. Usage of administrative large databases which rely on coding may lack granularity of clinical information such as pathogens, the exact spinal locations affected, or detailed records of surgical interventions. Furthermore, key clinical variables such as BMI or other nutritional parameters and laboratory findings are missing, limiting a potentially more comprehensive analysis. Malnutrition has a very board definition with a verity of underlying conditions. This complexity is not fully captured by ICD-coding. This data was yielded from 2020, which was significantly affected by the COVID-19 pandemic, altering clinical practices and hospital admissions in an unpredictable way. The full impact of these factors is yet to be understood. This may influence the accuracy of the reported results.

Conclusion

Malnutrition and hypoalbuminemia are relatively common in SD patients and are significant predictors of adverse outcomes such as in-hospital mortality and readmission.

A multidisciplinary, comprehensive treatment approach, including nutritional optimization, may reduce complications and lower both readmission and mortality rates. Routine assessment of albumin, as a cost-effective and rapid serological marker, could identify patients at risk, potentially improving outcome. By itself, however, hypoalbuminemia is an incomplete marker for the far more complex and diffuse clinical entirety of malnutrition. Further research focusing on pre- and post-operative nutritional support in SD treatment is needed.

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Author contributions
Conceptualization: J.G, J.C. R.O Methodology: J.G., C.P. J.C. Formal analysis and investigation: J.G., C.P. Writing - original draft preparation: J.G. C.P. Writing - review and editing: C.P., T.S., A.A, R.O., J.C. Resources: A.A, R.O., J.C. Supervision: A.A, R.O., J.C., T.S. All authors reviewed the manuscript.

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Data availability
The dataset is publicly available from the Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.

Declarations

Ethical approval
This retrospective study utilizes data from the 2020 Nationwide Readmission Database (NRD), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality. Therefore, no approval from an institutional and national research committee was needed.

Consent for publication
All authors have given a written declaration of consent for publication of the data obtained in this study. I confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

Competing interests
The authors declare no competing interests.

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