Original Paper

Nutritional Parameters and Short Term Outcome in Arthroplasty

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Objective: Advances in surgical techniques and management of arthroplasty patients have contributed to a significant reduction in surgical complication rates. Preoperative nutritional status has a significant impact on surgical outcome. Studies have reported improved outcomes in burn and hip fracture patients receiving nutritional supplementation during their recoveries. Our objective was to assess the effects of preoperative nutritional status on the incidence of complications, resource consumption, and length of stay of patients undergoing hip and knee replacement surgery.

Methods: One hundred and nineteen patients were evaluated. Standard preoperative laboratory tests were performed on all patients. Medical severity of illness was assessed on all patients using the Charlson Comorbidity Index. Anesthesia and surgical time was recorded. Short term outcome was assessed utilizing hospital charges as a measure of resource consumption, length of stay (LOS), in-hospital consults and the presence and number of complications during hospitalization. Non-parametric Kruskall Wallis and chi-square statistical analyses were performed. A p value $<.05$ was considered significant.

Results: Mean age was 64.6 years$\pm$15.62. 52.9% had osteoarthritis (OA), 4.2% had rheumatoid arthritis (RA), 5.9% had osteonecrosis (ON), 9.2% had a hip fracture and 28% had a failed total knee arthroplasty (TKA) or total hip arthroplasty (THA). Mean albumin and total lymphocyte count (TLC) were 38.5 g/L$\pm$4.78 SD and 1884 cells/μL$\pm$762 SD, respectively. Patients with albumin levels less than 34 g/L had 32.7% higher charges (\$50,108$\pm$8203 SE *vs.* \$33,720$\pm$1128 SE, $p < .006$), higher medical severity of illness ($p=.03$) and longer LOS (8.6$\pm$1.7 SE *vs.* 5.2$\pm$.356 SE days, $p<.001$). Patients with TLC less than 1200 cells/μL had higher charges (\$32,544$\pm$1050 SE *vs.* \$42,098$\pm$3122 SE, $p=.004$), longer LOS (5.7$\pm$.531 *vs.* 5.4 days$\pm$.368, $p=.004$) and anesthesia (242.85$\pm$17.55 SE *vs.* 198.6 min.$\pm$6.06 SE, $p=.02$) and surgical times (177.14 min.$\pm$17.57 SE *vs.* 120.21 min.$\pm$6.22 SE, $p=.002$) when compared with patients with TLC higher than 1200 cells/μL. These findings were still significant when adjusted for medical severity of illness and age.

Conclusions: Our data demonstrate that preoperative nutritional status is an excellent predictor of short term outcome. Serum albumin and TLC correlate with resource consumption, length of stay and operative time in patients undergoing joint replacement surgery. These parameters may be improved with nutritional supplementation prior to surgery.

INTRODUCTION

The effect of nutrition on medical and surgical outcome has been studied since the late 1930s. Increased complication and mortality rates in surgical patients were associated with clinical malnutrition [1]. In 1968, Dudrick and colleagues [2] published data on parenteral hyperalimentation and clearly demonstrated that adequate nutritional support could decrease morbidity and mortality to the level seen in well-nourished patients. Numerous papers reporting poor outcomes in malnourished patients followed these publications. Nutritional status was reported to affect recovery of burn and trauma patients [3]. In the general medical population, low albumin levels were associated with higher morbidity and mortality rates, increased length of stay

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Abbreviations: BMI=body mass index, LOS=length of stay, MANOVA=multivariate analysis of variance, SD=standard deviation, SE=standard error, TLC=total lymphocyte count.

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and readmissions. The malnourished surgical patient was also reported to have a higher incidence of postoperative infections [4].

Nutrition significantly affects the healing process. Patients with burns, sepsis or surgery enter a catabolic phase with a significantly increased nutritional demand. Postoperative loss of appetite decreases the exogenous caloric supply necessary for energy and wound healing. Proteins are then mobilized from lean body mass, such as skeletal muscle, to aid in this process during the perioperative period. Protein demand can be increased up to 35% while intake is significantly reduced [5].

The role of nutrition and diet in orthopedics was first reported by Cuthbertson in 1936 [6,7]. A higher complication rate was reported in patients with low albumin recovering from hip fractures [8]. This has also been observed in cerebral palsy patients undergoing surgery for scoliosis correction [9]. Few studies have tried to assess the importance of nutrition in joint replacement surgery.

Studies have reported a high incidence of subclinical malnutrition in patients undergoing orthopaedic surgical procedures [10]. Total protein, albumin, total lymphocyte count (TLC), transferrin levels and delayed hypersensitivity have been used as nutritional markers. The joint replacement population consists mostly of elderly patients. Studies suggest that these patients are at an increased risk of protein-calorie malnutrition [11,12,13].

Our objective of was to assess the effect of preoperative nutritional parameters on the short term outcome and resource consumption in patients undergoing joint replacement surgery.

METHODS

One hundred and nineteen patients admitted to Cedars Medical Center for unilateral arthroplasty of the hip or knee were included in this study. All patients were admitted between January 1 and December 31, 1997 and had a primary or revision arthroplasty by one of three orthopaedic surgeons (CJL, JE, and RP).

Standard preoperative laboratory tests were performed prior to surgery. Patients were grouped into normal and abnormal albumin and TLC levels. Albumin levels of 34 g/L or less and TLC less than 1200 cells/μL were considered the lower limit of normal. Preoperative medical questionnaires (CJL) and medical charts were reviewed for secondary medical diagnoses. Medical severity of illness was assessed utilizing the Charlson Comorbidity Index which takes into account the number as well as the severity of medical illness at the time of the surgical procedure [14]. Each disease was given a weight score, and the patients' total score was obtained by adding each individual disease score.

Anesthesia and surgical times were documented from the operating room records. Short-term surgical outcome parameters included hospital charges as a measure of health resource consumption, length of stay (LOS), the presence of in-hospital complications and the number of in-hospital medical or surgical consults obtained. Charges and LOS were provided by the chief financial officer of our hospital. Complications were defined as events that occurred during surgery or the preoperative period that could increase resource consumption. Length of stay in days was divided into four categories: 0–3, 4–6, 7–9 and >10 days. Likewise, three categories were used for the number of in-hospital consults and for the comorbidity index: 0, 1 and 2 or more. The resulting data were analyzed as ordinal variables.

Non-parametric Kruskall-Wallis, chi-square and stepwise multiple regression analysis were utilized on the statistical analysis. A p-value less than .05 was considered statistically significant.

RESULTS

The patient cohort consisted of 72 females (60.5%) and 47 males (30.5%) with a mean age (±SD) of 64.6±15.62 years (range: 22 to 93 years; median 67 years). Preoperative diagnoses are shown in Table 1. Seventy-eight primary (65.5%), 33 revision (27.7%) and eight hemiarthroplasty (6.72%) procedures were performed. Seventy-seven patients (64.7%) had general and 42 (35.2%) had regional anesthesia.

The mean albumin (±SD) for all patients was 38.5±4.78 g/L (range: 20 to 46 g/L; median 39). Twenty-two patients (18.5%) had albumin levels of 34 g/L or less. The mean (±SD) TLC was 1884±762 cells/μL (range: 608 to 6264; median 1827). Twenty-one patients (17.6%) had a TLC of less than 1200 cells/μL.

The mean (±SD) body mass index (BMI) in our study group was 27.02 kg/m^2±4.6. The average charge (±SD) for all patients was $36,750.58±20.118 (range $15,684–$206,604; median $33,106), with an average LOS of 5.9±4.9 days, mean number of in-hospital consults of 0.93±1.29 and an average anesthesia and surgical times of 212.72 minutes±72.14 and 138.71 minutes±75.14, respectively. The average comorbidity index score for all patients was 0.66. Table 2 shows the number as well as the percentage of comorbid medical conditions present at the time of surgery. Among the 119 patients, the overall complication rate was 26.1% (number of complications/number of patients). Two of six patients who presented more

Table 1. Preoperative diagnoses for patients undergoing total hip or knee arthroplasty

Diagnosis	n	% of total
Osteoarthritis	63	52.9
Rheumatoid Arthritis	5	4.2
Osteonecrosis	7	5.9
Hip Fracture	11	9.2
Failed Total Hip or Knee Arthroplasty	33	27.8

Table 2. Preoperative comorbid medical conditions

Medical Diagnoses	n*	%
Myocardial Infarction	13	10.9
Congestive Heart Failure	2	1.7
Peripheral Vascular Disease	7	5.9
Cerebrovascular Disease	6	5.0
Chronic Pulmonary Disease	10	8.4
Diabetes	10	8.4
Diabetes with end organ damage	0	0.0
Leukemia	7	0.8
Lymphoma	0	0.0
Dementia	3	2.5
Hemiplegia	1	0.8
Connective Tissue Disease	13	10.9
Mild Liver disease	3	2.5
Moderate to severe liver disease	0	0.0
Ulcer disease	8	6.7
AIDS	0	0.0
Any Tumor	5	4.2
Metastatic Tumor	0	0.0

* Number and percentage of all patients.
Medical conditions as assessed by the Charlson Comorbidity Index.

than one complication had albumin levels of less than 34 g/L. Table 3 shows the number as well as the percentage of complications in all patients divided by albumin levels.

As shown in Table 4 patients with an albumin of 34 g/L or less had statistically significant lower BMI (p<.001), higher charges (p=.006) and higher medical severity of illness (p=.03) when compared with those patients with albumin higher than 34 g/L. They also had longer LOS (p<.001). As shown in Table 5, patients with a TLC less than 1200 cells/μL had statistically significant longer anesthesia (p=.02) and surgical times (p=.002). They also had a higher number of in-hospital consults (p=.004) and higher charges (p=004). Patients with lower albumin and TLC were slightly older (65.18 *vs.* 64.54 years) and statistically sicker (assessed by the comorbidity index), than those with normal values. Stepwise multiple regression analysis was also performed using charges and surgical time as dependent variables and preoperative diagnosis, age, surgeon, albumin levels, TLC and complications as the independent variables. As shown in Table 6, admission diagnosis, surgeon complications and albumin levels were statistically significant predictors of charges and operative time.

Table 3. Postoperative complications following total hip and total knee arthroplasty

Complication	Albumin 34 g/L or less (n = 22)		Albumin > 34 g/L (n = 97)	
	n	%	n	%
Limitation of motion	0	0.00	1	1.03
Altered Mental State	0	0.00	2	2.06
Hemorrhage	0	0.00	1	1.03
Cardiovascular	0	0.00	4	4.12
Deep Infection	1	4.54	2	2.06
Vascular injury	0	0.00	1	1.03
Respiratory Failure	1	4.54	0	0.00
Death	1	4.54	0	0.00
Poor wound healing	0	0.00	2	2.06
Urinary and bladder disorders	0	0.00	2	2.06
Pneumothorax	0	0.00	1	1.03
DVT	0	0.00	0	0.00
Joint Instability	1	4.54	0	0.00
Fractures	1	4.54	1	1.03
Nerve Injury	0	0.00	1	1.03
Patellar problems	0	0.00	0	0.00
Other	1	4.54	6	6.18
Total*	6	27.27	23	23.71

* Total complications = number of complications/number of patients.
Two complications in one patient were counted as two separate complications.
DVT = deep venous thrombosis.

Table 4. Age, body mass index and short-term outcome parameters (mean ± SD): Patients with albumin levels less or higher than 34 g/L

	34 g/L or < (n=22)	>34 g/L (n=97)	p value
Age	65.18 ± 18.8	64.54 ± 14.9	.38
BMI	24.15 ± 4.1	27.68 ± 4.5	.001
Charges	$50,108.45 ± 38,476	$33,720.96 ± 11,113	.006
Anesthesia Time (min.)	228.04 ± 74.16	209.24 ± 71.6	.27
Surgical Time (min.)	162.27 ± 91.94	133.37 ± 70.25	.06
Consults	1.5 ± 2.2	0.08 ± .943	.12*
LOS (days)	8.68 ± 8.4	5.28 ± 3.5	.001*
Medical Comorbid Index	1.22 ± 1.2	0.61 ± .95	.03
Complications	27.27%	23.71%	.69*

* chi-square of dichotomized variables.
BMI = body mass index, LOS = length of stay.

DISCUSSION

Investigators have reported in the medical literature that patients with higher albumin levels have shorter hospital stays. Herrmann *et al.* [4] compared albumin levels to LOS in 15,511 patients. He found that there was a statistical difference in the LOS of patients with albumin levels below 34 g/L and those above this value (14.1±15.7 and 9.61±12.1, respectively). His study did not select orthopaedic patients and included all patients admitted to his institution.

Unfavorable results in malnourished patients have also been reported in surgical populations [15,16,17]. Patients with low albumin levels have increased postoperative morbidity and mortality. In the postsurgical catabolic state, patients who are better nourished heal faster, thereby shortening their hospital stay. In our study, those patients with low albumin levels were hospitalized an average of three days more than those with normal albumin levels. As shown in Table 3, all complications in patients with albumin levels of 34 g/L or less were major complications. This could account for the increased number of

Table 5. Age and short term outcome parameters (mean ± SD) in patients with total lymphocyte count lower or higher than 1200 cells/μL

	TLC <1200 cells/μL (n = 21)	TLC >1200 cells/μL (n = 98)	p value
Age	66.71 ± 19.2	65.0 ± 13.9	.64
BMI	24.87 ± 5.1	27.6 ± 4.8	.02
Charges	$42,098.52 ± 14,308	$32,544.26 ± 10,397	.004
Anesthesia time (min.)	242.85 ± 80.4	198.6 ± 59.9	.02
Surgical time (min.)	177.14 ± 80.5	120.21 ± 61.58	.002
In-hospital consults	1.38 ± 1.0	.73 ± 1.1	.004*
LOS (days)	5.7 ± 2.4	5.4 ± 3.6	.001*
Medical Comorbid Index	1.04 ± 1.1	0.73 ± 1.0	.22*
Complications	42.90%	23.50%	.1*

* chi-square of dichotomized variables.
BMI = body mass index, LOS = length of stay.

Table 6. Stepwise multiple regression analysis β coefficients and significance of variables that entered model (Charges as Dependent Variable)

	β Coefficient	SE	Significance
Diagnosis	1753.056	670.039	.010
Surgeon	−11191.64	3314.129	.001
Complication	−11031.45	3530.720	.002
Albumin Level	−10548.72	4295.135	.016

in-hospital specialist consultations and longer hospital stays observed in our study.

Low albumin levels have also been associated with higher mortality rates in hospitalized and surgical patients [18,19]. Corti *et al.* [20] reported that men 71 years or older, with hypoalbuminemia (<35 g/L), had a 1.9 times greater risk of death from any cause than men with normal albumin levels. Herrmann *et al.* looked at 15,511 patients' serum albumin level within the first 48 hours of admission as a predictor of death and readmission. The low-albumin group (<34 g/L) had a death rate of 14% and a mean readmission time of 97.2 days, while the normal albumin level group had a 4% death rate and a 109-day mean readmission time [4]. In our cohort, only one surgical procedure was complicated by death. This patient had a preoperative albumin level of 24 g/L.

Puskarich *et al.* [21] found TLC to have an 87.5% negative predictive value for patients developing infection after surgical fixation of long bone fracture. The positive predictive value was only 14.6%. Therefore, a low TLC value is not reliable in predicting possible infections, but patients with a higher TLC are unlikely to develop an infection. Delmi *et al.* [9] found that patients with fractured necks of the femur that were given nutritional supplementation for 32 days after admission had significantly better clinical outcomes. The complication and death rates were 44% for the supplemented group and 87% for the control groups. After six months these values were still lower for the supplemented group (40% *vs.* 74%).

The effects of preoperative nutritional status have been studied before in joint replacement. Gherini *et al.* [22] studied 103 hips in 92 patients and concluded that preoperative transferrin levels were predictors of delayed wound healing. Greene *et al.* [23] found a direct correlation of low TLC and albumin levels with wound complications in patients that underwent joint replacement. Del Salvio *et al.* reported that patients with albumin levels less than 39 g/L doubled their hospital stays, for the most part patients with preoperative diagnosis of osteonecrosis [24]. We did not find an increased risk of intrahospital infection or wound-healing problems in our group of patients; however, a longer follow-up might show an adverse effect in preoperative malnutrition on outcome.

Some authors have shown an inverse relationship between age and nutrition [10,11]. The average age in our two groups was very similar (64.54 *vs.* 65.18 years). Patients in our study with low albumin had a higher Charlson Comorbidity Index. Friedman *et al.* consider the presence of comorbid conditions as the most frequent cause of hypoalbuminemia [25]. Old age and comorbidities could therefore be confounding variables. In our study, there was no statistically significant correlation between age and albumin or TLC. We did not find age to be a confounding variable. Comorbid diseases were also analyzed as a confounding variable utilizing MANOVA, and our results continued to be statistically significant.

The senior author in this study routinely screened for preoperative nutritional parameters. In many cases, surgery was postponed until the patients were better nourished. This could explain the reduced number of patients with low albumin and TLC in our cohort. Out of all patients studied, 22 had albumin levels below 34 g/L. Stepwise multiple regression analysis showed that preoperative diagnosis was the most important predictor of hospital charges and surgical time. Patients with hip fractures had lower preoperative mean albumin levels than the rest of the cohort, but this was not statistically significant (3.3273±.573 *vs.* 3.9065±.435, p=.388). Our results demonstrate that low albumin levels are predictors of short-term outcome after arthroplasty for all patients, but especially for hip fracture patients.

In this study, we included primary, revision and hemiarthroplasty procedures. Multiple regression analysis was performed and surgical procedure was not found to be a confounding variable.

This study emphasizes the importance of assessing nutritional status preoperatively. The orthopedic surgeon should be aware of the increased surgical risk in the malnourished patient. Increased surgical and anesthesia times, longer LOS and more in-hospital consults signify greater health-resource consumption. With continuously increasing health care costs, it is important to identify factors that reliably predict short-term outcome.

CONCLUSIONS

We recommend that a patient with an albumin of 34 g/L or less and a TLC less than 1200 cells/μL should not be considered for elective joint replacement surgery until nutritional problems are corrected with the appropriate intervention. A simple and inexpensive test, such as albumin and CBC with a differential, together with dietary supplementation prior to surgery, could help reduce short-term complications.

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