Does Risk for Malnutrition in Patients Presenting With Fractures Predict Lower Quality Measures?

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Introduction: The purpose of this study was to determine if nutritional screening could be used as a predictor for the development of complications and hospital readmissions.

Methods: A variation of the Malnutrition Universal Screening Tool (MUST) score was collected for all inpatients with orthopaedic trauma on admission to our hospital from 2009 to 2011. We retrospectively compared each patient's MUST score with the subsequent development of infection, venous thromboembolism, respiratory failure, ulceration, or readmission. Finally, a chart review was performed to collect comorbidity data and evaluate Charlson comorbidity indexes to estimate the overall health of each patient with an available MUST.

Results: Of the 796 consecutive patients in our total cohort, 57.7% (n = 459) were of normal nutritional status and 42.3% (n = 337) exhibited at least 1 sign of malnutrition. In patients with normal nutrition, 2.8% developed at least one of the specified complications, and we observed a complication-to-patient ratio of 0.033. In patients with signs of malnutrition, 8.0% developed at least 1 complication with a complication-to-patient ratio of 0.101. This difference was significant (P = 0.001). Multivariate regression analysis demonstrated that each additional point in a patient's nutrition score corresponded to a 49.5% increase in the odds of developing a complication when controlling for other factors (odds ratio = 1.495, confidence interval = 1.120–1.997, P = 0.006). Charlson comorbidity indexes were not significantly associated with total complications when MUST scores used were a covariant.

Discussion and Conclusions: Patients treated for fractures and dislocations with any sign of malnutrition according to the MUST score were more than twice as likely to acquire some combination of infection, venous thromboembolism, respiratory failure, or other reason for readmission than those of normal nutritional status. Increasing levels of malnourishment corresponded with increasing risk for developing complications, whereas these complications were not necessarily associated with higher comorbidity. An assessment of a fracture patient's nutritional status should be considered a factor in evaluating risks related to fracture care. The MUST score is a predictive tool. These data have important implications for hospitals whose fiscal reimbursement is dependent on the maintenance of defined quality measures.

Key Words: nutrition, malnutrition, outcomes, quality measures, PE, VTE, infection, readmission, orthopaedic trauma, trauma

Level of Evidence: Prognostic Level II. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

The association between malnutrition and poor surgical outcome in elective surgery is well established. Multiple studies, in fields as disparate as otolaryngology and gynecologic surgery, have linked malnutrition to increases in mortality, ICU admissions, infections, and wound healing time.[1–6] As large studies have shown that 40%–55% of hospitalized patients are malnourished,[4] the importance of nutrition in surgical outcomes cannot be overstated.

Within the field of orthopaedics, a number of studies comparing pretreatment nutritional status and posttreatment complication rates have observed positive correlations, suggesting the significance of pretreatment nutrition. These studies include those performed in the context of hip fracture,[7–10] general orthopaedic surgery,[11–13] and arthroplasty.[14–16] However, unlike elective surgeries, patients with orthopaedic trauma often cannot have their nutritional status optimized before surgery. The posttraumatic stress state is characterized by the rapid mobilization of protein coupled with inadequate intake, and patients undergoing surgery assume an additional 10%–30% increase in total energy expenditure within 24 hours after treatment.[1,17] Basic science studies have shown that this protein deprivation has a profound detrimental effect on fracture healing.[18,19] These effects are particularly severe among elderly patients with hip fracture, for whom the probability of survival 1 year after injury has been observed to be significantly lower among protein-depleted individuals.[20]

Most previous studies investigating the effect of malnutrition on surgical patients focused on optimizing preoperative nutrition status to obtain the best outcomes.[9,16,21–23] The few studies that have looked at nutritional status as a predictor of outcomes have used biomarkers such

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as serum albumin or total lymphocyte counts as a proxy for nutritional status.[7,8,13,20,24] However, using biomarkers to assess baseline nutrition in patients with orthopaedic trauma requires additional blood work, increases cost, and is not routinely performed in many hospitals.

In the United States, hospitals accredited by the Joint Commission are required to perform a nutritional screening within 24 hours of a patient's admission when warranted by specific conditions or needs.[25,26] In our hospital, all patients admitted to an inpatient service receive a nutrition screening on admission by a certified nutritionist or—more recently—the nursing department. Although a number of methods are available to assess or screen for nutritional risk in a clinical setting, our institution uses a variation of the Malnutrition Universal Screening Tool (MUST) to assess nutrition risk, which accounts for intake/appetite patterns, diagnoses/feeding modality, recent unintended weight loss, and the severity of pressure ulcers (Table 1).[14] The potential advantage of using the MUST score over biomarkers to assess nutrition status is that the MUST score does not require any additional invasive tests, procedures, or costs beyond what is already used by the hospital. The purpose of this study was to determine if baseline malnutrition as assessed by the MUST score could be used as a predictor for the development of complications and hospital readmissions. Our null hypothesis is that the MUST score is not predictive of future complications and readmissions.

PATIENTS AND METHODS

We analyzed the charts of every patient admitted as an inpatient to our hospital from 2009 to 2011. Our data set was restricted to visits related to orthopaedic trauma, identified by primary or secondary diagnostic fracture *ICD-9* codes between 808.0 (pelvis) and 838.3 (foot). Inclusion criteria for age was 20 years or older. A variation of the MUST was administered at our institution as part of the inpatient screening process.[14,27] Its primary purpose, as mandated by the Joint Commission, was to evaluate a hospitalized patient's risk for malnutrition. This screening tool involves the grading of several variables; in each one, a grade of 0 signifies a healthy individual and 1 or greater signifies increasing levels of risk as indicated in Table 1. The variables are then added together to obtain a total score. In a healthy individual with a total score of 0, the risk for developing malnutrition is considered low; higher total scores represent a heightened risk for malnutrition. Patients screened with higher scores are monitored more frequently for changes in nutritional status. Thus, it is possible for an individual to have multiple nutrition scores associated with a single visit. Only the initial screening score for a full visit was used. In the process of extracting these scores, we also collected age, body mass index (BMI), and complete blood count (CBC) results.

TABLE 1. Nutrition Screening Criteria Based on the MUST

Variable	Grade	Score
Intake/appetite: percent of normal	Good (75%–100%)	0
	Fair (51%–74%)	1
	Poor (<51%)	2
Diagnosis/feeding modality	Good (75%–100%)	0
	Fair (51%–74%)	1
	Poor (<51%)	2
Unintended weight loss >10% in 1 mo	No	0
	Yes	2
Pressure ulcer severity	None	0
	Stage I–II	2
	Stage III–IV	3
Total score		13

Data processing involved the consolidation of the same-day intrainstitutional transfers into single visits and the filtering of BMI values under the second percentile or exceeding the 98th percentile to mitigate metabolic outliers. Furthermore, any patients with multiple visits were treated as unique cases, with the assumption that one's nutritional status could change at different points in time.

Complication records were retrieved from our Quality and Infection Control departments. Complication categories were matched with their respective visits during our initial data collection phase, after which all patient identifiers were removed. Major complication categories relevant to nutrition were consolidated into 6 general groups: infection (including postoperative sepsis, procedure-related infection, surgical site infections, *Clostridium difficile*, catheter-associated infections, and urinary tract infections), venous thromboembolism (VTE, which included deep vein thrombosis and pulmonary embolism), postoperative respiratory failure, ulceration, death, and readmission. This observational retrospective study was qualified as exempt by our institutional review board. All analyses were performed on de-identified data untraceable to original patient records.

Finally, a manual chart review was performed for each patient with an available MUST score to account for the presence of comorbidities. These data formed the basis for evaluating Charlson comorbidity index (CCI) values and age-adjusted CCIs to assess the overall health of patients in our cohort.[28] The CCI is a validated tool that is used to predict risk of death.

Statistical Analysis

In addition to evaluating descriptive statistics, we performed multivariate regression analyses to evaluate correlations between a number of independent variables on overall complication rates. In addition to the MUST score for nutritional status, we looked at injury factors as a surrogate for injury severity, age, BMI, and CBC for general patient health. The overall presence of any complication—infection, VTE, postoperative respiratory failure, ulceration, or readmission—for a given visit was treated as a binary ordinal variable ("overall complication"). The independent variables included MUST score, age, age-adjusted CCI, binary BMI (inside vs. outside the healthy range of 18.5–25), injury classification, and CBC consisting of 5 ordinal values: hemoglobin, mean corpuscle volume, platelet count, red blood cells, and white blood cells. All of these were assigned either a "low," "normal," or "high" with respect to standard ranges. Injury classification consisted of 3 variables: location ("upper extremity," "pelvis,"

and "lower extremity"), open versus closed, and fracture versus dislocation.

A total of 2 multivariate regression analyses were performed: one considered MUST score as continuous ("Continuous MUST"), whereas the other considered MUST score as binary where any value greater than 0 was labeled as 1 ("Binary MUST"). In the Binary MUST calculation, patients with scores of 0 were assigned as group A, where patients with scores of 1 or greater were assigned as group B. Mann–Whitney *U* tests were used to determine differences in complication rates between group A and group B.

Finally, to assess the effects of patient general health, we used MUST scores (either Binary or Continuous) and CCIs (either CCI or age-adjusted CCI) to generate 4 separate multivariate regressions analyses to predict total complications.

RESULTS

We identified 17,782 inpatient visits between 2009 and 2011 at our large urban non-level 1 University Hospital, of which 16,113 corresponded to patients aged 20 years and older. Nine hundred nine admissions were associated with *ICD-9* codes from 808.0 (pelvis) to 838.3 (foot), of which 796 (87.6%) had associated MUST scores. Our analyses were subsequently performed on this cohort, which will be referred to as the total cohort. The chart review of comorbidity data among the total cohort of 796 yielded 694 CCIs and age-adjusted CCIs (87.2%).

Figure 1 shows a histogram of the overall distribution of MUST scores in the form of a Pareto chart. Within the total cohort, 459 patients (57.7%) were screened with a MUST score of 0 (group A), whereas 337 (42.3%) had a MUST score of 1 or above (group B). In this context, group A represents those patients with a normal level of baseline nutrition.

A total of 14 infections, 9 VTEs, 2 respiratory failures, 1 ulceration, and 23 readmissions were identified within our total cohort, as summarized in Table 2. There were 0 deaths. These complications were not evenly distributed among groups A and B. The overall complication rate was 2.8% in group A and 8.0% in group B, whereas specific complication rates were generally lower in group A than group B, as illustrated in Figure 2. An exception was the single case of ulceration from group A compared with 0 in group B. These differences were significant for total complications, infection, and readmission.

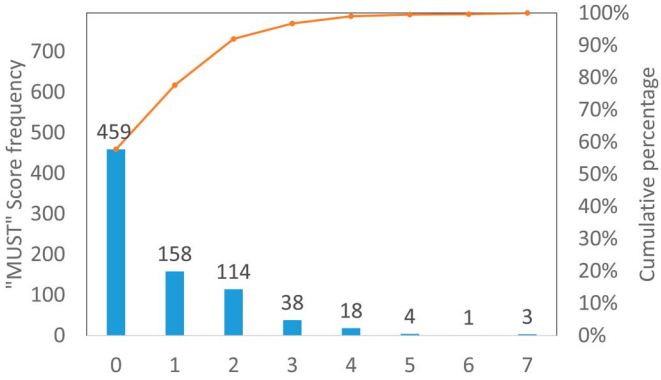

FIGURE 1. The distribution of MUST scores in the total cohort (n = 796). Patients with a normal baseline nutritional status are defined by a MUST score of 0. We observed 42.3% of patients with a MUST score greater than 0. **Editor's note:** A color image accompanies the online version of this article.

TABLE 2. Observed Complication Rates Between Normal and Malnourished Patients

	Group A: Total Score = 0 (n = 459)	Group B: Total Score >0 (n = 337)	Statistically Significant ($P < 0.05$)
Prevalence of at least 1 complication	2.8%	8.0%	0.001
Complication counts			
Infection	3	11	0.011
Deep vein thrombosis/ pulmonary embolism	3	6	No
Respiratory failure	0	2	No
Ulceration	1	0	No
Readmission	8	15	0.031
Death	0	0	No

In the multivariate regression analyses, the MUST score was the only independent variable significantly associated with overall complication when adjusting for all other variables. The odds ratios (OR) for Binary and Continuous MUST were 3.807 (95% confidence interval = 1.505–9.627, $P = 0.005$) and 1.495 (95% confidence interval = 1.120–1.997, $P = 0.006$), respectively.

Finally, when MUST scores (Binary or Continuous) and CCIs (CCI or age-adjusted CCI) were used to generate the 4 multivariate regressions predicting total complications, the OR for nutrition score were confirmed to remain significant, whereas the OR for CCI were not (Table 3).

DISCUSSION AND CONCLUSIONS

In our cohort, the prevalence of elevated risk for malnutrition among adult patients with orthopaedic trauma was high (42%). This is consistent with previously published results for inpatient malnutrition status.[4] MUST scores were a strong predictor of the future development of complications, thus disproving our null hypothesis. The prevalence of complications (any), VTE, infection, respiratory failure, and readmission were all at least twice as high among patients at risk for malnutrition (defined as patients with MUST scores of 1 or greater) in comparison with patients at low risk (defined as patients with a MUST score of 0) regardless of the comorbidity status. This difference was significant for total complications, infection, and readmission. Furthermore, based on our regression analysis for MUST score as a continuous variable, each additional point in a patient's nutrition score corresponded to a 49.5% increase in the odds of developing a complication.

The use of nutrition screening as a predictive tool is beneficial on multiple levels. As nutritional screenings are already performed on most patients on admission to the

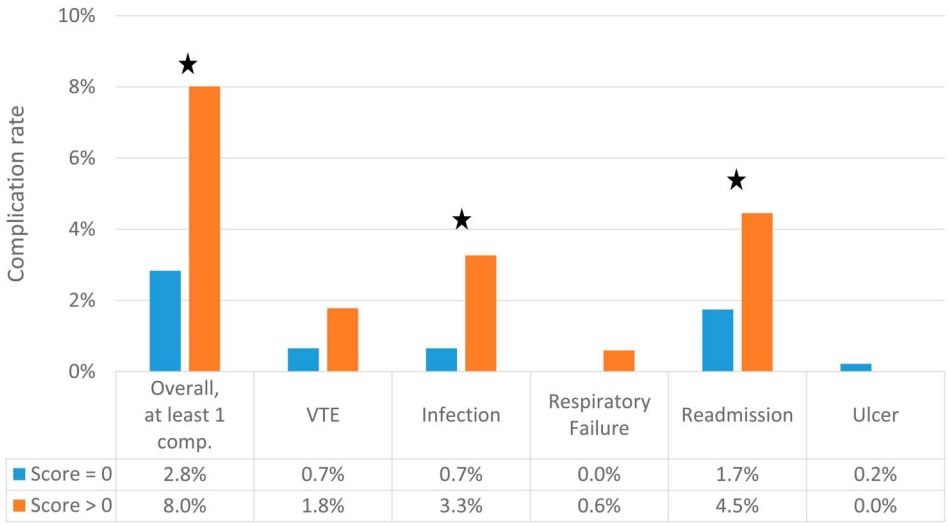

FIGURE 2. Summary of complication rates (overall and specific) between group A and group B. Patients with a MUST score of 0 (group A) generally developed complications at a lower rate than those exhibiting 1 or more signs of malnutrition (group B). This difference was statistically significant for total complication, infection, and readmission (indicated with ★). **Editor's note:** A color image accompanies the online version of this article.

hospital, little to no additional screening costs are needed. It is also not invasive, as no blood work is needed. Furthermore, when nutritional screening is performed for patients with orthopaedic trauma, an assessment protocol that examines multiple markers enables an institution to capture a broader range of variables. Such an approach has several advantages over relying on 1 single biochemical marker as a screening tool, as has been previously described. For instance, Lawson et al and Fuhrman et al argue that although low serum albumin levels can be effectively used as both an indicator of malnutrition and predictor of complications in the preoperative setting, it is likely to be of limited value during the screening process for patients who are hospitalized or already undergoing physiological stress due to inflammation or infection.[25,29] In these cases, preserum albumin levels would be of greater value as a monitoring tool for nutritional repletion over time. In our own evaluation, BMI alone as a continuous variable did not correlate nearly and the overall screening score in predicting complication. In contrast, results from the multivariate regressions demonstrate a positive correlation between our institution's nutrition screening scores and complication rates.

Although the Binary MUST variable has been demonstrated to be a useful screening tool for identifying patients with orthopaedic trauma at higher risk for malnutrition and complications, blood tests evaluating combinations of serum biomarkers are likely to provide greater specificity and sensitivity as diagnostic tools. A previously cited study evaluating total lymphocyte count, serum albumin, serum prealbumin, and serum transferrin levels in elderly patients sustaining hip fractures (n = 63) demonstrated sensitivity and specificity in predicting complications of 91% and 48%, respectively.[20] That is, of the total patients sustaining complications, 91% tested positive for nutritional depletion, whereas of the total patients who did not sustain any complications, 48% tested negative. Although the sensitivity observed in this study was likely positively influenced by a more limited category of fractures—hip—and cohort age range—the elderly—it establishes a benchmark for comparison. The disadvantages of relying on multiple serum biomarkers to evaluate nutritional depletion in patients with orthopaedic trauma include the additional cost and turnaround time associated with ordering blood tests—negatively influencing their cost effectiveness as screening tools.

We evaluated the performance of the Binary MUST variable as a diagnostic tool for predicting complications and observed a sensitivity of 68% and specificity of 59%—a lower sensitivity but higher specificity than the benchmark described in the preceding paragraph. Orthopaedic trauma cases requiring higher accuracy in predicting complication rates should consider the use of multiple serum biomarkers; that said, the lower costs of evaluating MUST scores and demonstrated association with complication rates positively influence their cost effectiveness as a screening tool. As such, MUST scores remain an attractive measure, which could be integrated into an institution's evidence-based quality improvement "toolkit" toward identifying patients requiring additional nutritional support.

The ability to predict risk for future complications based on nutrition status is extremely useful because of the high morbidity, mortality, and cost associated with inpatient malnutrition. Correia and Waitzberg[30] in a study of 709 nonobstetric adult patients found that hospital costs for malnourished patients were 308.9% greater than well-nourished patients. Freijer et al[31] reported that in 2011, the total additional cost of managing adult patients with disease-related malnutrition in the Netherlands was estimated to be €1.9 billion. By identifying which patients may be malnourished and thus more likely to develop a complication or be readmitted, we can mitigate costs by giving these patients aggressive nutrition therapy and better counsel at risk patients on the likely outcomes of orthopaedic treatments.

This study was limited because of its retrospective design. There was also a small percentage of our cohort (12.4%) that did not receive a nutrition screening, despite meeting all other inclusion criteria. As it is likely that most of these patients were determined to be a low risk for malnutrition, it is possible that we may have missed a small number of complications primarily in group A. However,

TABLE 3. Comparison of Results Between Studies Using Laboratory Screening Versus MUST Scores to Assess Malnourishment

Authors	Year	Total Cohort	Context	Percent Malnourished	Malnutrition Criteria	Malnourishment Predictive of
Koval et al[7]	1999	490	Hip fracture	18% (low albumin) to 57% (low TLC)	Albumin <3.5 g/dL	Increased length of stay and inhospital mortality
					TLC <1500 cells/mL	Increased 1-year mortality
					Low albumin + low TLC	Increased length of stay, 1-year mortality; decreased recovery of independence
Foster et al[8]	1990	40	Hip fracture	NA	Serum albumin, serum transferrin, anthropometric measurements, skin testing for delayed hypersensitivity, total lymphocyte count, 24 h during collection for metabolic and nitrogen balance	Elevated mortality rate
Jensen et al[13]	1982	129	THA	29%	Triceps skinfold, arm-muscle circumference, creatinine: height index, serum transferrin, serum albumin, total lymphocyte count, skin antigen testing	Higher prevalence of complications
			Elective surgery	35%		
			Fractures	59%		
Patterson et al[20]	1992	63	Hip fracture	58%	Serum albumin, serum prealbumin, serum transferrin, total lymphocyte count, nitrogen balance studies	Higher prevalence of complications, lower likelihood to return to prefracture environment, increased length of stay, higher 1-year mortality
Nicholson et al[24]	2012	90	Elective THA for osteoarthritis	30%	Serum albumin, total lymphocyte count	Increased length of stay
		10	Trauma-related THA	86%		
		32	Trauma-related hip hemiarthroplasty			
This investigation	2014	796	Orthopaedic trauma	42%	MUST-based nutrition screening tool	Increased total complications, infection, readmission

NA, not available; THA, total hip arthroplasty; TLC, total lymphocyte count.

given the low overall rate of complications and the highly significant differences in complication and readmission rates between group A and group B, we do not believe this would have greatly affected our results. It is quite evident that baseline nutritional status can be affected by a number of factors, such as chronic disease or malnourishment. Our analysis solely investigated the effectiveness of nutritional screening as an outcome predictor. Malnutrition is not the only factor to consider when looking at complications associated with fracture. General health of patients and the severity of injury play a role. Our center from which these cases were reviewed is not a level 1 trauma center, and therefore injury severity score is not recoded in any case and thus not available for analysis. We attempted to substitute various specific injury factors to assess these variables effect on development of complications and found no correlation. Although almost all of these patients represent 1 system involvement and thus would have similar injury severity score scores, it is possible that some patients may have had multisystem involvement, which could have lead to a higher complication rate. Finally, not all patients underwent surgery and thus American Society of Anesthesia grades would not be available on all patients.

Inpatient malnutrition is a known contributor to morbidity, mortality, and cost. We have confirmed that malnutrition occurs at extremely high rates in the orthopaedic trauma population. With these data, we can reject our null hypothesis. Furthermore, we found that nutritional screening is highly predictive of posttreatment complications and readmission. Nutritional screening using the MUST score is a simple, inexpensive, and more accurate method for assessing

nutritional risk in patients with orthopaedic trauma than a number of previously described methods relying on single biomarkers. Although circumstances demanding a higher degree of sensitivity or specificity in assessing complication risk should warrant more advanced testing, it may not be cost effective to obtain multiple serum biomarkers on all patients with fracture and the MUST score can serve to identify patients in whom obtaining these tests may make sense. These data have important implications for hospitals invested in their patients' health and whose fiscal reimbursement is dependent on the maintenance of defined quality measures.

REFERENCES

1. Enomoto TM, Larson D, Martindale RG. Patients requiring perioperative nutritional support. *Med Clin North Am.* 2013;97:1181–1200.
2. Bertrand PC, Piquet MA, Bordier I, et al. Preoperative nutritional support at home in head and neck cancer patients: from nutritional benefits to the prevention of the alcohol withdrawal syndrome. *Curr Opin Clin Nutr Metab Care.* 2002;5:435–440.
3. Bruun LI, Bosaeus I, Bergstad I, et al. Prevalence of malnutrition in surgical patients: evaluation of nutritional support and documentation. *Clin Nutr.* 1999;18:141–147.
4. Gallagher-Allred CR, Voss AC, Finn SC, et al. Malnutrition and clinical outcomes: the case for medical nutrition therapy. *J Am Diet Assoc.* 1996; 96:361–366. 369; quiz 367–368.
5. Fearon KC, Luff R. The nutritional management of surgical patients: enhanced recovery after surgery. *Proc Nutr Soc.* 2003;62:807–811.
6. Kathiresan AS, Brookfield KF, Schuman SI, et al. Malnutrition as a predictor of poor postoperative outcomes in gynecologic cancer patients. *Arch Gynecol Obstet.* 2011;284:445–451.
7. Koval KJ, Maurer SG, Su ET, et al. The effects of nutritional status on outcome after hip fracture. *J Orthop Trauma.* 1999;13:164–169.
8. Foster MR, Heppenstall RB, Friedenberg ZB, et al. A prospective assessment of nutritional status and complications in patients with fractures of the hip. *J Orthop Trauma.* 1990;4:49–57.
9. Eneroth M, Olsson UB, Thorngren KG. Nutritional supplementation decreases hip fracture-related complications. *Clin Orthop Relat Res.* 2006;451:212–217.
10. Egol KA, Strauss EJ. Perioperative considerations in geriatric patients with hip fracture: what is the evidence? *J Orthop Trauma.* 2009;23:386–394.
11. Ozkalkanli MY, Ozkalkanli DT, Katircioglu K, et al. Comparison of tools for nutrition assessment and screening for predicting the development of complications in orthopedic surgery. *Nutr Clin Pract.* 2009;24:274–280.
12. Smith TK. Prevention of complications in orthopedic surgery secondary to nutritional depletion. *Clin Orthop Relat Res.* 1987;222:91–97.
13. Jensen JE, Jensen TG, Smith TK, et al. Nutrition in orthopaedic surgery. *J Bone Joint Surg Am.* 1982;64:1263–1272.
14. Schwarzkopf R, Russell TA, Shea M, et al. Correlation between nutritional status and Staphylococcus colonization in hip and knee replacement patients. *Bull NYU Hosp Jt Dis.* 2011;69:308–311.
15. Greene KA, Wilde AH, Stulberg BN. Preoperative nutritional status of total joint patients. Relationship to postoperative wound complications. *J Arthroplasty.* 1991;6:321–325.
16. Huang R, Greenky M, Kerr GJ, et al. The effect of malnutrition on patients undergoing elective joint arthroplasty. *J Arthroplasty.* 2013;28 (8 suppl):21–24.
17. Garden OJ, Bradbury AW, Forsythe JLR, et al. *Principles and Practice of Surgery: With Student Consult Online Access*. London, United Kingdom: Elsevier Health Sciences; 2012.
18. Day SM, DeHeer DH. Reversal of the detrimental effects of chronic protein malnutrition on long bone fracture healing. *J Orthop Trauma.* 2001;15:47–53.
19. Jones CB. Biological basis of fracture healing. *J Orthop Trauma.* 2005; 19(10 suppl):S1–S3.
20. Patterson BM, Cornell CN, Carbone B, et al. Protein depletion and metabolic stress in elderly patients who have a fracture of the hip. *J Bone Joint Surg Am.* 1992;74:251–260.
21. Gallagher-Allred CR, Voss AC, Koop KL. The effect of medical nutrition therapy on malnutrition and clinical outcomes. *Nutrition*. 1999;15: 512–514.
22. Goiburu ME, Goiburu MM, Bianco H, et al. The impact of malnutrition on morbidity, mortality and length of hospital stay in trauma patients. *Nutr Hosp.* 2006;21:604–610.
23. Gusberg R, Gump FE. Combined surgical and nutritional management of patients with acute mesenteric vascular occlusion. *Ann Surg.* 1974;179: 358–361.
24. Nicholson JA, Dowrick AS, Liew SM. Nutritional status and short-term outcome of hip arthroplasty. *J Orthop Surg (Hong Kong).* 2012;20:331–335.
25. Lawson CM, Daley BJ, Sams VG, et al. Factors that impact patient outcome: nutrition assessment. *J Parenter Enteral Nutr.* 2013;37(5 suppl):30S–38S.
26. Mueller C, Compher C, Ellen DM. A.S.P.E.N. clinical guidelines: nutrition screening, assessment, and intervention in adults. *J Parenter Enteral Nutr.* 2011;35:16–24.
27. Anthony PS. Nutrition screening tools for hospitalized patients. *Nutr Clin Pract.* 2008;23:373–382.
28. Charlson M, Szatrowski TP, Peterson J, et al. Validation of a combined comorbidity index. *J Clin Epidemiol.* 1994;47:1245–1251.
29. Fuhrman MP, Charney P, Mueller CM. Hepatic proteins and nutrition assessment. *J Am Diet Assoc.* 2004;104:1258–1264.
30. Correia MI, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. *Clin Nutr.* 2003;22:235–239.
31. Freijer K, Tan SS, Koopmanschap MA, et al. The economic costs of disease related malnutrition. *Clin Nutr.* 2013;32:136–141.