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AAHKS Symposium: Modifying Risk Factors: Strategies that Work

Patient Optimization—Strategies That Work: Malnutrition

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ABSTRACT

Background: Patient optimization is receiving increasing attention as outcomes monitoring and bundled payments have been introduced in joint arthroplasty. Optimization of nutrition is an important aspect of perioperative management.
Methods: This manuscript is a review of previously published material related to nutrition and the impact of malnutrition on surgical outcomes, with guidance for surgeons preparing patients for elective joint arthroplasty.
Results: Patients with optimized nutritional parameters have fewer complications, especially related to wound healing and infection.
Conclusion: Nutritional assessment and optimization should be a part of the perioperative management of patients undergoing lower extremity arthroplasty.

In an era of medicine in which outcomes are increasingly tied to data tracking and reporting as well as reimbursement, and bundled payments for joint replacement have begun, new emphasis has been placed on the concept of patient optimization before surgical intervention. Recognition and management of malnutrition is one facet of patient optimization that can positively impact outcomes in arthroplasty. Malnutrition has been associated with delayed wound healing, persistent drainage, and prosthetic joint infection in orthopedic patients [1-3].

The purpose of this review is to outline the definition of malnutrition, to aid the surgeon in identification of patients at risk, and to suggest appropriate assessments and interventions that can be used to optimize prospective arthroplasty patients.

Definition of Malnutrition

Malnutrition is defined as a state resulting from lack of uptake or intake of nutrition leading to altered body composition (decreased fat-free mass but specifically body cell mass) and diminished function [4]. This includes over nutrition as well as undernutrition. Malnutrition has not traditionally been a focus of intervention by orthopedic surgeons, but it has significant effects on surgical outcomes [4-7].

Malnutrition in these studies has been defined as serum albumin less than 3.5 or absolute lymphocyte count less than 1500, whereas other studies have used other markers such as transferrin or prealbumin. However, these values are not absolute and have been questioned in several studies [8-12]. In a consensus agreement reached through series of meetings held at the American Society for Enteral and Parenteral Nutrition and European Society for Parenteral and Enteral Nutrition congresses, malnutrition was classified into 3 groups: starvation-related, chronic disease–related, and acute injury– or disease state–related group [13]. Classifying malnutrition based on etiology simplifies the issue and also helps determine appropriate management strategies.

Prevalence of Malnutrition

Malnutrition has been reported to be as high as 20%-50% in hospitalized patients [14] and while the prevalence of malnutrition in orthopedic patients has been reported as 9%-39% [15,16]. Furthermore, malnutrition was identified in 26% of arthroplasty patients at an urban academic center [17], and other studies report this incidence as high as 50% [3,18].

Malnutrition and Immunity

Nutritional factors play a crucial role in regulating metabolic pathways and immune system functions. Various nutritional factors that have been implicated to play a role in patients undergoing arthroplasty include serum albumin, serum iron/transferrin, vitamin D, serum zinc, and adiposity.

Protein deficiency causes atrophy of lymphoid organs affecting several immune functions such as lymphocyte proliferation,

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antibody responses, Interleukin-2 (IL-2), and Interferon-gamma as well as delayed-type hypersensitivity reactions [19]. Recent study has shown human albumin has an immunomodulatory effect leading to an increased ability of antigen presenting cells to trigger T-cell activation [20]. Iron sequestration provides innate defense termed nutritional immunity, where a single substitution in transferrin reverses TbpA binding to counteract bacterial piracy [21]. Composition of adipose tissue is regulated by body weight status, feeding, and fasting. Hypertrophy and hyperplasia of adipocytes lead to decreased vascularity and subsequent necrosis followed by macrophage infiltration and inflammation. T cells infiltrating adipose tissue produce Th1 cytokines such as IL-1, Interferon gamma, IL-6, and leptins, which are responsible for chronic inflammation as well as insulin resistance [22]. The nutritional importance of zinc is well known, but its role in immunomodulation has been recognized more recently. Zinc deficiency affects both innate and adaptive immunity in acute situations, and chronic deficiency leads to an increase in the production of proinflammatory cytokines leading to inflammatory states [23].

Although vitamin D has a well-recognized role in bone health, it also plays an important role in innate immunity [24]. The immunomodulatory actions of vitamin D are well recognized and are a key factor in innate as well as adaptive immunity and immunity modulation [25]. Immunologically competent cells such as B and T lymphocytes, monocytes as well as dendritic cells display specific vitamin D receptors [26]. Circulating vitamin D levels have direct influence on macrophages and increase their oxidative burst potential [27] (maturation and production of cytokines, acid phosphatase, and hydrogen peroxide) and prevents excessive expression of inflammatory cytokines. Vitamin D may also improve outcomes by reducing both local and systemic inflammatory response as a result of modulating cytokine responses and reducing toll-like receptor activation [28]. It also stimulates expression of potent antimicrobial peptides, such as cathelicidin and beta-defensin 2. Similarly, vitamin C has also been implicated as an important nutritional parameter. Vitamin C has well-recognized antioxidant properties and has been used in arthroplasty to reduce systemic inflammatory response syndrome [29]. It is also known to have immunostimulant, antibacterial, and antiviral properties and has been advocated to reduce regional pain syndrome [30].

Malnutrition and Arthroplasty

Using an institutional computerized database, 11,785 consecutive total hip arthroplasty (THA) and total knee arthroplasty (TKA) were reviewed. Three hundred patients had persistent drainage, and 83 patients failed initial debridement. In this study, late debridement and malnutrition (35%) predicted failure of debridement with component retention and subsequent development of prosthetic joint infection [31].

In a more recent study, 49,603 primary THA or TKA patients were retrospectively reviewed using the American College of Surgeons National Surgical Quality Improvement Project database. Hypoalbuminemia was identified in 4.0% of cases and was associated with a 2-fold increase in the rate of surgical site infection. This study also demonstrated independent associations between hypoalbuminemia and pneumonia, prolonged hospital length of stay as well as readmission [7]. In a previous study by the same author, of 9230 revision THA or TKA patients in the ACS-NSQIP registry, 4517 had recorded serum albumin and 755 (15.8%) were found to have hypoalbuminemia. This cohort was 3 times more likely to have a septic indication for revision than patients with normal albumin [32]. A prospective study of 213 patients undergoing total knee replacement used triceps skinfold thickness as a marker for nutritional status. There was 5% risk of infection when triceps skinfold thickness was below 30 mm and 10% risk when it was below 20 mm [33]. Hypoalbuminemia has been identified as a more significant risk factor for postoperative complications than morbid obesity [34].

Nelson et al [35] using the NSQIP database, analyzed 77,785 surgical patients. They grouped patients as morbidly obese (body mass index [BMI] $\geq$40) or nonmorbidly obese (BMI $\geq$18.5-<40) or by low serum albumin level <3.5 mg/dL) or normal serum albumin (serum albumin level $\geq$3.5 mg/dL). They found that low serum albumin independently predicted higher mortality than the group with normal serum albumin (0.64% vs 0.15%; odds ratio [OR], 3.17; 95% confidence interval, 1.58-6.35; $P = .001$). They also found that patients in the low serum albumin group were more likely to have a superficial surgical site infection (1.27% vs 0.64%; OR, 1.27); deep surgical site infection (0.38% vs 0.12%; OR, 3.64); organ space surgical site infection (0.45% vs 0.15%; OR, 2.71); pneumonia (1.21 vs 0.29); require unplanned intubation (0.51% vs 0.17); and remain on a ventilator more than 48 hours (0.38% vs 0.07%). Malnourished patients were found to have a higher incidence of renal insufficiency (0.45% vs 0.12%; OR, 2.71); acute renal failure (0.32% vs 0.06%; OR, 5.19); cardiac arrest requiring cardiopulmonary resuscitation (0.19% vs 0.12%; OR, 3.74); and septic shock (0.38% vs 0.08%; OR, 4.4). Patients in the low serum albumin group also were more likely to require blood transfusion (17.8% vs 12.4%; OR, 1.56; 95% confidence interval, 1.35-1.81; $P < .001$).

Vitamin D insufficiency has been implicated with poor functional outcomes, an increase postoperative pain, and increased risk for periprosthetic infection [36,37]. Examining the National Health and Nutrition Examination Survey 2005-2006 using a cutoff of $\leq$20 ng/mL, the prevalence of vitamin D insufficiency was found to be 41.6% [38]. Johnson et al [39], comparing 448 patients with hip fractures and a control group of 1091 patients, all of whom underwent elective total hip or total knee replacement, showed that there was high rate of vitamin D insufficiency in both groups (cutoff of 30 ng/mL) with prevalence of 65.8% in the fracture group and 54% in the arthroplasty group. In a recent study [40], examining 9135 patients from the Australian Diabetes, Obesity and Lifestyle study, 201 hip arthroplasties for osteoarthritis were identified. In this study, they found that a one standard deviation increase in 25-hydroxy-vitamin D in males was associated with a 25% increase in incidence of arthroplasty. In a retrospective study, Maier et al [36] found 86% of patient undergoing revision arthroplasty for periprosthetic infection having vitamin D level below 20 ng/mL. In the same study, they also found 64% of primary arthroplasty patients and 52% of patients undergoing revision arthroplasty for aseptic loosening having vitamin D insufficiency.

Similarly, low serum zinc level has been correlated with delayed wound healing in total hip arthroplasty as well as hemiarthroplasty. The cutoff value is less than 95 microgram/dL. In a prospective study, Zorrilla et al [41] found that low serum zinc level and absolute lymphocyte count of less than 1500 significantly correlated with delayed wound healing in total hip arthroplasty patients.

Identification of Patients at Risk

Obesity, low BMI, prior gastric bypass, malabsorption states, and hyper metabolic states can increase risk of malnutrition. World Health Organization defines obesity as a BMI >30. The average BMI for patients undergoing arthroplasty in the United States is 33. The most common reason for obesity is excess caloric intake. Although excess calories lead to obesity, many obese patients do not have adequate nutrition, as high-calorie diets tend to contain foods high in carbohydrates and fat and limited true nutritional value. Many centers now set a cutoff of BMI 40 or lower before arthroplasty. Simple advice for patients to lose weight is inadequate. Calorie