Current Geriatrics Reports (2022) 11:33–39
https://doi.org/10.1007/s13670-020-00343-5

GERIATRIC PSYCHIATRY (C QUATMAN AND C QUATMAN-YATES, SECTION EDITORS)

Nutritional Considerations in Geriatric Orthopedics

Tyler Youngman[1] · Dustin Rinehart[1] · Megan Sorich[1] · Jennifer Oberstar[2] · Teresa McCarthy[2]

Accepted: 29 October 2020 / Published online: 7 January 2021

Abstract

Purpose of Review Malnourished patients are at risk for fragility fractures resulting in postoperative complications, increased mortality, and decreased functional status after geriatric orthopedic surgeries. Nutritional status of the older patient can be determined by various screening tools. We aim to review recent literature on nutritional status in preoperative and postoperative evaluations and determine its implications for geriatric orthopedic surgery patients.

Recent Findings Malnutrition has been associated with increased orthopedic surgery complications. An individualized nutrition screening and treatment plan can reduce these complications and prevent future fragility fractures. Interleukin-6 is an inflammatory cytokine that may be useful in the prediction of mortality and nutritional status of the patient; however, further research is necessary.

Summary A nutritional screening tool can be utilized to determine at-risk individuals. Nutrition should be optimized prior to undergoing an orthopedic procedure, and an interdisciplinary team approach is recommended.

Keywords Orthopedic nutrition · Geriatric nutrition · Malnutrition · Fragility fracture · Preoperative · Postoperative

Introduction

By 2050, there will be approximately 83.7 million Americans aged 65 and over [1]. As the population ages in the USA, the prevalence of fractures in older people continues to climb. Fragility fractures as a result of aging and osteoporosis are projected to account for over 3 million fractures per year by 2025 [2]. For patient who sustains hip fractures, only half of patients recover to their pre-fracture level of independence for activities of daily living [3]. One factor affecting not only the rate of fractures but the outcomes associated with fractures and the subsequent healthcare burden is the nutritional status of the older patient. It has been reported that 3.2% of all hospitalized patients annually are considered malnourished [4•, 5]. The geriatric population specifically is at the greatest risk of malnourishment. While less than 5% of community dwellers are malnourished, approximately 30% of residents in long term and rehabilitation institutions are considered malnourished [6]. Additionally, 58.3% of acutely hospitalized patients over age 65 are considered malnourished [5]. The association between the physical function status of the older adult as it pertains to their ability to perform basic self-care and nutritional status has been found to be significant [7–10]. It is not difficult to extrapolate how nutritional status of the geriatric orthopedic patient can impact outcomes including complication rates, length of hospital stay, and overall mortality rates. We sought to examine recent literature for current information on the impact of nutrition on orthopedic care and advances being made in screening and treatment for malnutrition in the geriatric orthopedic patient population.

History and Advances in Markers of Nutrition

Malnourished patients are often identified with the use of a screening tool. Multiple governing bodies have attempted to provide consensus-based criteria for screening of malnutrition, including the European Society for Clinical Nutrition and Metabolism and the American Society for Enteral and Parental Nutrition. Commonly utilized variables within these screening tools include evaluation for reduction of food intake, body mass index, and weight loss during a defined period of time [11]. The Mini Nutritional Assessment is a more

This article is part of the Topical Collection on *Geriatric Orthopedics*

✉ Teresa McCarthy
mccar056@umn.edu

[1] University of Texas Southwestern Medical Center, Dallas, TX, USA

[2] University of Minnesota, Minneapolis, MN, USA

sensitive tool compared to the screening tools that are designed specifically for an older population [12]. Rubenstein et al. demonstrated that the Mini Nutritional Assessment had the best specificity in identifying those patients at risk for malnutrition [13]. While screening and risk assessment is an initial step, it is imperative to look at factors that drive malnutrition once at-risk patients are identified. Favaro-Moreira et al. identified a range of risk factors for malnutrition including polypharmacy, oral dysphagia, needing assistance to eat, constipation, loss of grip strength, dementia, and frailty as defined by deterioration of body function [14]. There is a plethora of objective data measures to assess nutritional risk in a patient. Historically albumin, prealbumin, transferrin, and CRP have been utilized as laboratory markers for nutritional status [15]. Bohl et al. examined the effect an albumin level < 3.5 g/dL had on survival after geriatric hip fractures. They demonstrated that geriatric patients undergoing surgery for a hip fracture with documented hypoalbuminemia had higher rates of death, sepsis, unplanned intubation, and increased mean length of stay compared to a retrospective cohort of geriatric patients with albumin levels > 3.5 g/dL [16]. It should be noted that while each of the biological nutrition markers paint a global picture, there are inherent flaws in each substrate. Albumin has a long half-life, thus rendering it less useful for acute changes. Additionally, transferrin is dependent on the iron status of the patient [17].

Other nutritional markers have been assessed to try to better identify at-risk populations. Interleukin-6 (IL-6) is an inflammatory cytokine known to be elevated in trauma patients [18]. Qiao et al. even demonstrate in a meta-analysis that IL-6 can be used to predict mortality in trauma patients [19]. IL- 6 can also be used to evaluate the nutritional status of a patient. Bian et al. demonstrated that sarcopenia, or loss of muscle mass, in the elderly correlated with elevated IL-6 and TNF-alpha [20].

The primary role of circulating IL-6 is to maintain energy status in skeletal muscle. However, a sustained elevation of IL-6, in the absence of adequate nutrient supplementation which is required to offset the effects of IL-6, has been shown to accelerate muscle degradation [21]. The malnourished, sarcopenic, geriatric population essentially lives in a chronic state of heightened inflammation. A cohort with median follow-up of 11 years demonstrated that an elevated baseline level of IL-6 was associated with higher incidence of hip fractures in women and older patients [22]. Saribal et al. evaluated IL-6 and tumor necrosis factor-alpha levels in geriatric hip fractures and matched the fracture cohort with uninjured controls. IL-6 was shown to significantly spike higher from baseline postoperative day 1 and 2 [23]. Given the acute increase in IL-6 known to occur during trauma, Kaiser et al. examined the impact this has on fracture healing. They discovered that inhibition of a specific sub-molecule of IL-6 called IL-6-trans actually enhanced bony healing in the fracture gap. This suggested that IL-6 facilitated negative effects on bone repair [24, 25]. The study was limited by the fact that global inhibition of all IL-6 sub-molecules did not impact effectiveness of bony healing. IL-6 is becoming an important molecule for not only prediction of hip fracture risk but the subsequent healing potential given chronic elevation of IL-6 in the geriatric population as described above. Measuring serum IL-6 levels has seen theoretical advancements with decrease in result times to within 24 min compared to 4 to 5 h [26]. IL-6 is not yet approved for use. While there is some evidence that tocilizumab in rheumatoid arthritis patients leads to increased bone mineral density through IL-6 modulation, thus far there are no clear therapies that target IL-6 trans-signaling in patients without rheumatoid arthritis for the purpose of increasing bone health [27].

Preoperative Considerations

Elective Preoperative Considerations

An aging population and the advent of improved technology in the field of arthroplasty have increased the prevalence of elective total knee, hip, and shoulder arthroplasty procedures [28, 29]. As a result, patients are turning to their primary care provider for preoperative evaluation for these elective procedures. In the geriatric population, preoperative optimization and risk evaluation are comprehensive including the assessment of the following: cognition, polypharmacy, functional status, nutrition, and cardiac and pulmonary risk [30, 31]. Thus, it is easy to overlook a patient's nutritional status during the preoperative screening process. Screening for malnutrition should be assessed by both the orthopedic surgeon and primary care provider. A recent publication found that 11.5% of patients undergoing elective arthroplasty had an albumin of < 3.4 g/l. Length of stay and readmission rates were reduced when at-risk patients with low albumin were transitioned to a high protein (100 g/day) and an anti-inflammatory diet. According to this study, an anti-inflammatory diet limits the intake of sugar, saturated fats, simple carbohydrates, and red meat. An anti-inflammatory diet consists of increased fish, nuts, seeds, fruits, vegetables, and whole grains [32••].

In a meta-analysis by Gu et al., patients with serologic markers of malnutrition (hypoalbuminemia, decreased total lymphocyte count, or transferrin) were at an increased risk for poor postoperative outcomes, including wound complications [33••]. After identifying those patients who are malnourished or at risk of malnutrition, an interdisciplinary team base approach should be taken to optimize these patients prior to any operative intervention [34].

In both the nourished and malnourished patient, a new concept focusing on enhanced recovery after surgery (ERAS) has emerged. It involves all aspects of surgery with the goal of reducing complications and length of hospital stay

[35]. Preoperatively, nutrition supplementation utilizing carbohydrate loading and immunonutrition theoretically reduces stress associated with surgery [36]. Studies have shown that preoperative carbohydrate loading has reduced postoperative insulin resistance [37]. However, while the efficacy of carbohydrate loading has not consistently conferred a benefit compared to placebo, a reduction in hospital stay compared to fasting has been demonstrated [38]. Immunonutrition involves nutritional supplementation with glutamine, arginine, omega-3 fatty acids, and nucleotides prior to elective surgery. This has been theorized to modulate the postsurgical inflammatory and immunosuppression response [39, 40]. However, no studies pertaining to immunonutrition currently exist in orthopedic literature.

Urgent/Emergent Preoperative Considerations

For the geriatric patient who sustains a fragility fracture, optimization of preoperative nutrition is not possible. In the orthopedic literature, a delay of greater than 48 h to hip fracture fixation has been linked to increased rates of complications and mortality [41, 42]. As a result, many patients are admitted and begin their preoperative fasting in preparation of operative intervention.

Regardless of scheduled surgery time, a patient is made NPO at midnight and frequently fast longer than required. The updated American Society of Anesthesiologists practice guidelines recommend oral clear liquids up to 2 h and a light meal up to 6 h prior to procedure in an effort to reduce the fasting period [43]. Despite these recommendations, up to 25% of patients admitted for hip fracture will receive no oral intake leading up to surgery [44]. In an effort to reduce the duration of preoperative fasting, studies have looked at the benefits of preoperative carbohydrate drinks up to 2 h before surgery. Hospitalized patients had improved postoperative discomfort and reduced insulin resistance without pulmonary aspiration [45]. In light of these studies, nurses and physicians should be educated about the ability of patients to consume clear liquids up to 2 h before surgery.

Postoperative Considerations

Wound healing, bone healing, and surgical site infection are examples of major concerns in this acute postoperative period. Many studies have closely linked malnutrition with postoperative complications and mortality. Malnourished patients who sustain hip fractures have a threefold increased mortality at 1 year compared to those who are well-nourished [46]. Not only do these patients experience a higher risk of requiring an assistive device postoperatively, they also are more likely to lose independence. It is estimated that 10 to 20% of geriatric orthopedic patients are newly institutionalized into a long-term care facility following a hip fracture [47]. Further compounding the problem, 18–21% of institutionalized elderly experience undernutrition [48]. In a meta-analysis, the risk of surgical site infection in orthopedic patients was 2.5 times higher when albumin was < 3.5 mg/d/L [49]. Vitamin D and calcium are well-known contributors to the fracture healing process and found to be globally deficient in the elderly [50, 51]. He et al. demonstrated that supplementation three times daily of an enteral nutrition powder (a form of Ensure) that contained many vitamins and minerals including vitamin D and calcium, in hip fracture patients with hypoalbuminemia, reduced the risk of wound complications and the length of hospital stay [52•]. Even by postoperative day 3, the cohort treated with oral ensure powder demonstrated a significant increase in albumin levels [52•]. Because hospitalization tends to decrease oral intake at baseline, this poses a challenge. Simply improving the presentation of a meal and access to the food by helping the patient cut and open their food containers can increase consumption in hospitalized patients [53]. Ensuring that the patient has proper dentition along with the correct food consistency available will increase oral intake. Oral intake will be increased when patients have proper food consistency and good dentition. Additionally, enriching the protein in foods the elderly are already intimately familiar with has been shown to increase protein intake significantly in the institutionalized [48].

While wound healing is an immediate postoperative issue, bone healing occurs over a longer period of time. A randomized controlled trial by Torbergsen et al. examined bone turnover markers in orthogeriatric hip fracture patients. They found decreased levels of bone turnover markers in the serum when vitamin D and vitamin K consumption was increased providing evidence for focused mineral supplementation to improve recovery in bone metabolism after hip fracture [54]. The intestinal biome may also play a role as probiotic treatment in a double-blind placebo-controlled clinical trial showed promise in accelerating the recovery period of older patients with distal radius fractures [55]. Prevention of further injury in the postoperative setting is also a key. Frequent exercise, balance training, and vitamin D supplementation has been shown effective at reducing falls in institutionalized older residents after several months. An interdisciplinary approach during acute care and rehabilitation phases after geriatric fracture improved the outcomes [56]. To improve patient care and their outcomes, a focused team approach especially with the supervision of a qualified nutritional staff is ideal.

Preventative Measures in the Community

For the geriatric patient, sustaining a fragility fracture significantly reduces independence and quality of life and increases

risk of mortality [57]. Therefore, focus has been turned to prevention and identification of steps to reduce the incidence of these fractures. In 2009, the American Orthopedic Association launched the "Own the Bone" initiative to provide education surrounding fragility fractures. Other steps include bone mineral density screening, pharmacologic therapy, and mobile outreach programs [58, 59•].

Osteoporosis increases fracture risk due to decreased bone mineral density. Screening and treatment for osteoporosis is the mainstay in the prevention of fragility fractures. Osteoporosis is diagnosed after bone mineral density screening reveals a T-score of less than or equal to − 2.5 or a FRAX greater than or 3% for 10-year probability of hip fracture or greater than 20% for major osteoporotic fracture [60]. Modifiable risk factors such as smoking, alcohol intake, and nutrition should be identified and addressed with the osteoporotic patient.

From a nutrition standpoint, prevention, identification, and treatment of malnutrition in the geriatric patient are vital. Malnourished patients have a 45% increased risk of falls compared to their well-nourished cohort [61]. As many studies point out, malnourished patients with hip fractures are at increased risk of death within that year [16, 62, 63].

Recommendations for nutritional supplementation with vitamin D and calcium vary by age and gender. Studies recommend at least 800–1000 IU of vitamin D per day and 1000–1200 mg of calcium daily [64]. Chronic hyponatremia has also been linked to osteoporosis and puts the patient at an increased risk of falls and subsequent fragility fractures [65]. Initiation of treatment after identification of osteoporosis and those at risk for fragility fractures has led to a reduction in fracture risk for these patients [66].

For geriatric patients who sustain a fragility fracture, it is important to prevent a secondary fracture. Wrist and vertebral compression fractures are known independent risk factors for subsequent hip fractures in both men and women [67]. In 2019, the American Society for Bone and Mineral Research provided recommendations for secondary fracture prevention [68]. Regarding nutritional supplementation, the panel recommended initiating at least 800 IU of vitamin D per day and calcium supplementation for those unable to intake 1200 mg/day from food sources [68]. Oral anti-osteoporosis (bisphosphonate) pharmacologic therapy should be initiated while in the hospital. Previously, bisphosphonates were thought to delay fracture healing; however, newer studies have called that into question [69–71].

Conclusion

Nutrition of geriatric patients plays a crucial role in not only bone health but overall health. Screening patients for malnutrition at routine visits and preoperatively will reduce complications associated with orthopedic surgery. For patients who sustain a hip fracture, nutritional status is a strong predictor of mortality, and interventions to minimize malnourishment may help improve outcomes. Prevention of these fractures with screening for osteoporosis, malnutrition, and intervening with nutritional supplementation with vitamin D, vitamin K, and calcium is a key. Fragility fractures will reduce a patient's independence and quality of life and increase mortality risk. An interdisciplinary, team-based approach should be utilized for improving nutrition in the geriatric population.

Summary of recommended interventions to improve outcomes in malnourished elderly with hip fractures

Component	Intervention	Effect
Preoperative interventions Comprehensive preoperative physical	• Individualized intervention based on preoperative findings • Comprehensive team-based assessment • Nutritional assessment	• Decreased hospital stay • Decreased wound complications • Improved postoperative outcomes • Improved nutritional status • Improved fracture healing
Preoperative laboratory testing Low albumin Low ferritin Low total lymphocyte count	• Carbohydrate loading • Optimized nutritional labs	• Decreased hospital stay • Improved postoperative outcomes • Decreased wound complications
Urgent emergent	• Limit NPO status • Clear liquids • Carbohydrate drinks	• Reduced insulin requirements • Improved postoperative discomfort
Postoperative interventions	• Optimized nutrition • Optimized calcium and vitamin D • Provide familiar foods	• Increased wound healing • Increased bone healing • Decreased surgical site infection • Increased oral intake
Prevention	• Treatment of osteoporosis with bisphosphates • Optimization of calcium and vitamin D • Optimization on nutritional status	• Decreased fracture • Improved patient strength, walking speed, and nutritional status

Compliance with Ethical Standards

Conflict of Interest None.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. Ortman JM, Velkoff VA, Hogan H. An aging nation: the older population in the United States. Washington, DC: United States Census Bureau, Economics and Statistics Administration, US Department of Commerce; 2014.
2. Burge R, Dawson-Hughes B, Solomon DH, Wong JB, King A, Tosteson A. Incidence and economic burden of osteoporosis-related fractures in the United States, 2005–2025. JBMR. 2007;3:465–75. https://doi.org/10.1359/jbmr.061113.
3. Bentler SE, Liu L, Obrizan M, Cook EA, Wright KB, Geweke JF, et al. The aftermath of hip fracture: discharge placement, functional status change, and mortality. Am J Epidemiol. 2009;170(10):1290–9. https://doi.org/10.1093/aje/kwp266.
4.• Lim PN, Ooi LJ, Ong T, Neighbour C, Sahota O. Pelvic fragility fractures in older people admitted to hospital: the clinical burden. Eur Geriatr Med. 2019;10(1):147–50. https://doi.org/10.1007/s41999-018-0131-6 **This article looks at the clinical course of pelvic fragility fractures. The authors found that pelvic fragility fractures are associated with worse inpatient and post-discharge clinical outcomes, without specific interventions. This is an older multi-morbid cohort needing significant post-fracture rehabilitation care. Their care in hospital needs to address their management complexities including the numerous medical problems, nutritional deficiencies and rehabilitation potential. This article helps highlight the different co-management teams, especially nutrition required to successfully care for these older adults.**
5. Corkins MR, Guenter P, DiMaria-Ghalili RA, Jensen GL, Malone A, Miller S, et al. American Society for Parenteral and Enteral Nutrition. Malnutrition diagnoses in hospitalized patients: United States, 2010. J Parenter Enter Nutr. 2014;38(2):186–95. https://doi.org/10.1177/0148607113512154.
6. Cereda E, Pedrolli C, Klersy C, Bonardi C, Quarleri L, Cappello S, et al. Nutritional status in older persons according to healthcare setting: a systematic review and meta-analysis of prevalence data using MNA®. Clin Nutr. 2016;35(6):1282–90. https://doi.org/10.1359/jbmr.061113.
7. Shahar S, Ibrahim Z, Abdul Fatah AR, Abdul Rahman S, Yusoff NAM, Arshad F, et al. A multidimensional assessment of nutritional and health status of rural elderly Malays. Asia Pac J Clin Nutr. 2007;16(2):346–53.
8. Oliveira MR, Fogaça KC, Leandro-Merhi VA. Nutritional status and functional capacity of hospitalized elderly. Nutr J. 2009;8(1):54. https://doi.org/10.1186/1475-2891-8-54.
9. Olasunbo OI, Olubode KA. Socio-demographic and nutritional assessment of the elderly Yorubas in Nigeria. Asia Pac J Clin Nutr. 2006;15(1):95–101.
10. Agarwalla R, Saikia AM, Baruah R. Assessment of the nutritional status of the elderly and its correlates. J Fam Community Med. 2015;22(1):39–43. https://doi.org/10.4103/2230-8229.149588.
11. Poulia KA, Klek S, Doundoulakis I, Bouras E, Karayiannis D, Baschali A, et al. The two most popular malnutrition screening tools in the light of the new ESPEN consensus definition of the diagnostic criteria for malnutrition. Clin Nutr. 2017;36(4):1130–5. https://doi.org/10.1016/j.clnu.2016.07.014.
12. Marshall S, Young A, Bauer J, Isenring E. Malnutrition in geriatric rehabilitation: prevalence, patient outcomes, and criterion validity of the scored patient-generated subjective global assessment and the mini nutritional assessment. J Acad Nutr Diet. 2016;116(5):785–94. https://doi.org/10.1016/j.jand.2015.06.013.
13. Rubenstein LZ, Harker JO, Salvà A, Guigoz Y, Vellas B. Screening for undernutrition in geriatric practice: developing the short-form Mini-Nutritional Assessment (MNA-SF). J Gerontol A Biol Sci Med Sci. 2001;56(6):M366–72. https://doi.org/10.1093/gerona/56.6.M366.
14. Fávaro-Moreira NC, Krausch-Hofmann S, Matthys C, Vereecken C, Vanhauwaert E, Declercq A, et al. Risk factors for malnutrition in older adults: a systematic review of the literature based on longitudinal data. Adv Nutr. 2016;7(3):507–22. https://doi.org/10.3945/an.115.011254.
15. Bharadwaj S, Ginoya S, Tandon P, Gohel TD, Guirguis J, Vallabh H, et al. Malnutrition: laboratory markers vs nutritional assessment. Gastroenterol Rep. 2016;4(4):272–80. https://doi.org/10.1093/gastro/gow013.
16. Bohl DD, Shen MR, Hannon CP, Fillingham YA, Darrith B. Della valle CJ. Serum albumin predicts survival and postoperative course following surgery for geriatric hip fracture. J Bone J Surg Am. 2017;99(24):2110–8. https://doi.org/10.2106/JBJS.16.01620.
17. Dellière S, Cynober L. Is transthyretin a good marker of nutritional status? Clin Nutr. 2017 Apr 1;36(2):364–70. https://doi.org/10.1016/j.clnu.2016.06.004.
18. Jawa RS, Anillo S, Huntoon K, Baumann H, Kulaylat M. Interleukin-6 in surgery, trauma, and critical care part II: clinical implications. J Intensive Care Med. 2011;26(2):73–87. https://doi.org/10.1177/0885066610384188.
19. Qiao Z, Wang W, Yin L, Luo P, Greven J, Horst K, et al. Using IL-6 concentrations in the first 24 h following trauma to predict immunological complications and mortality in trauma patients: a meta-analysis. Eur J Trauma Emerg S. 2018;44(5):679–87. https://doi.org/10.1007/s00068-017-0880-9.
20. Bian AL, Hu HY, Rong YD, Wang J, Wang JX, Zhou XZ. A study on relationship between elderly sarcopenia and inflammatory factors IL-6 and TNF-α. Eur J Med Res. 2017;22(1):25. https://doi.org/10.1186/s12877-018-1007-9.
21. Hennigar SR, McClung JP, Pasiakos SM. Nutritional interventions and the IL-6 response to exercise. FASEB J. 2017;31(9):3719–28. https://doi.org/10.1096/fj.201700080R.
22. Stojanović D, Bůžková P, Mukamal KJ, Heckbert SR, Psaty BM, Fink HA, et al. Soluble inflammatory markers and risk of incident fractures in older adults: the cardiovascular health study. J Bone Miner Res. 2018;33(2):221–8. https://doi.org/10.1002/jbmr.3301.
23. Saribal D, Hocaoglu-Emre FS, Erdogan S, Bahtiyar N, Okur SC, Mert M. Inflammatory cytokines IL-6 and TNF-α in patients with hip fracture. Osteoporos Int. 2019;30(5):1025–31. https://doi.org/10.1007/s00198-019-04874-2.
24. Kaiser K, Prystaz K, Vikman A, Haffner-Luntzer M, Bergdolt S, Strauss G, et al. Pharmacological inhibition of IL-6 trans-signaling improves compromised fracture healing after severe trauma. Naunyn-Schmiedeberg's Arch Pharm. 2018;391(5):523–36. https://doi.org/10.1007/s00210-018-1483-7.
25. Prystaz K, Kovtun A, Kaiser K, Heidler V, Kroner J, Haffner-Luntzer M, et al. Role of interleukin-6 in the early and late fracture healing phase. 43rd Annual European Calcified Tissue Society Congress. BioScientifica. 2016;5:P54. https://doi.org/10.1530/boneabs.5P54.
26. Koyama K, Ohba T, Ishii K, Jung G, Haro H, Matsuda K. Development of a quick serum IL-6 measuring system in rheumatoid arthritis. Cytokine. 2017;95:22–6. https://doi.org/10.1016/j.cyto.2017.02.002.
27. Garbers C, Heink S, Korn T, Rose-John S. Interleukin-6: designing specific therapeutics for a complex cytokine. Nat Rev Drug Discov. 2018;17(6):395–412. https://doi.org/10.1038/nrd.2018.45.
28. Kremers HM, Larson DR, Crowson CS, Kremers WK, Washington RE, Steiner CA, et al. Prevalence of Total hip and knee replacement

in the United States. J Bone Joint Surg Am. 2015;97(17):1386–97. https://doi.org/10.2106/JBJS.N.01141.

29. Harjula JNE, Paloneva J, Haapakoski J, Kukkonen J, Äärimaa V. Increasing incidence of primary shoulder arthroplasty in Finland - a nationwide registry study. BMC Musculoskelet Disord. 2018;19(1):245. https://doi.org/10.1186/s12891-018-2150-3.
30. Kumar C, Salzman B, Colburn JL. Preoperative assessment in older adults: a comprehensive approach. Am Fam Physician. 2018;98(4): 214–20.
31. Chon T, Ma A, Mun-price C. Perioperative fasting and the patient experience. Cureus. 2017;9(5):e1272. https://doi.org/10.7759/cureus.1272.
32.•• Schroer WC, Lemarr AR, Mills K, Childress AL, Morton DJ, Reedy ME. Chitranjan S. Ranawat award: elective joint arthroplasty outcomes improve in malnourished patients with nutritional intervention: a prospective population analysis demonstrates a modifiable risk factor. Bone Joint J. 2019;101-B(7_Supple_C):17–21. https://doi.org/10.1302/0301-620X.101B7.BJJ-2018-1510.R1 **This is the first study to date that prospectively demonstrates a shorter length of hospital stay, a significantly lower primary hospitalization cost, and lower total 90-day charges in patients with preoperative hypoalbuminaemia who were encouraged to initiate a high protein, anti-inflammatory diet prior to elective total joint arthroplasty. This highlights malnutrition as a modifiable risk factor that impacts healthcare economics and improves postoperative outcomes.**
33.•• Gu A, Malahias MA, Strigelli V, Nocon AA, Sculco TP, Sculco PK. Preoperative malnutrition negatively correlates with postoperative wound complications and infection after Total joint Arthroplasty: a systematic review and meta-analysis. J Arthroplast. 2019;34(5):1013–24. https://doi.org/10.1016/j.arth.2019.01.005 **Gu et. al performed a systematic review of twenty studies which correlated serologic markers (albumin, total lymphocyte count, and transferrin) to postoperative wound complications and infection after total joint arthroplasty. The authors demonstrate that an albumin < 3.5 g/dl was associated with an increase in wound complications (odds ratio of 2.18, 95% confidence interval 1.92-2.47). This article emphasizes the importance of patient nutritional optimization prior to elective total joint arthroplasty.**
34. Reber E, Strahm R, Bally L, Schuetz P, Stanga Z. Efficacy and Efficiency of Nutritional Support Teams. J Clin Med. 2019;8(9): E1281. https://doi.org/10.3390/jcm8091281.
35. Soffin EM, Yadeau JT. Enhanced recovery after surgery for primary hip and knee arthroplasty: A review of the evidence. Br J Anaesth. 2016;117(suppl 3):iii62–72. https://doi.org/10.1093/bja/aew362.
36. Qureshi R, Rasool M, Puvanesarajah V, Hassanzadeh H. Perioperative nutritional optimization in spine surgery. Clin Spine Surg. 2018;31(3):103–7. https://doi.org/10.1097/BSD.0000000000000579.
37. Ljungqvist O, Nygren J, Thorell A. Modulation of post-operative insulin resistance by pre-operative carbohydrate loading. Proc Nutr Soc. 2002;61(3):329–36.
38. Amer MA, Smith MD, Herbison GP, Plank LD, Mccall JL. Network meta-analysis of the effect of preoperative carbohydrate loading on recovery after elective surgery. Br J Surg. 2017;104(3): 187–97. https://doi.org/10.1002/bjs.10408.
39. Bharadwaj S, Trivax B, Tandon P, Alkam B, Hanouneh I, Steiger E. Should perioperative immunonutrition for elective surgery be the current standard of care? Gastroenterol Rep (Oxf). 2016;4(2):87–95. https://doi.org/10.1093/gastro/gow008.
40. Probst P, Ohmann S, Klaiber U, Hüttner FJ, Billeter AT, Ulrich A, et al. Meta-analysis of immunonutrition in major abdominal surgery. Br J Surg. 2017;104(12):1594–608. https://doi.org/10.1002/bjs.10659.
41. Anthony CA, Duchman KR, Bedard NA, Gholson JJ, Gao Y, Pugely AJ, et al. Hip fractures: appropriate timing to operative intervention. J Arthroplast. 2017;32(11):3314–8. https://doi.org/10.1016/j.arth.2017.07.023.
42. Fu MC, Boddapati V, Gausden EB, Samuel AM, Russell LA, Lane JM. Surgery for a fracture of the hip within 24 hours of admission is independently associated with reduced short-term post-operative complications. Bone Joint J. 2017;99(9):1216–22. https://doi.org/10.1302/0301-620X.99B9.BJJ-2017-0101.R1.
43. Practice Guidelines for Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration: Application to Healthy Patients Undergoing Elective Procedures: An Updated Report by the American Society of Anesthesiologists Task Force on Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration. Anesthesiology. 2017;126(3):376–393. https://doi.org/10.1097/ALN.0000000000001452
44. Dixon J, Channell W, Arkley J, Eardley W. Nutrition in hip fracture units: contemporary practices in preoperative supplementation. Geriatr Orthop Surg Rehabil. 2019;10:2151459319870682. https://doi.org/10.1177/2151459319870682.
45. Noba L, Wakefield A. Are carbohydrate drinks more effective than preoperative fasting: a systematic review of randomised controlled trials. J Clin Nurs. 2019;28(17–18):3096–116. https://doi.org/10.1111/jocn.14919.
46. van Wissen J, van Stijn MF, Doodeman HJ, Houdijk AP. Mini nutritional assessment and mortality after hip fracture surgery in the elderly. J Nutr Health Aging. 2016;20(9):964–8. https://doi.org/10.1007/s12603-015-0630-9.
47. Dyer SM, Crotty M, Fairhall N, Magaziner J, Beaupre LA, Cameron ID, et al. A critical review of the long-term disability outcomes following hip fracture. BMC Geriatr. 2016;16(1):158. https://doi.org/10.1186/s12877-016-0332-0.
48. Beelen J, de Roos NM, De Groot LC. Protein enrichment of familiar foods as an innovative strategy to increase protein intake in institutionalized elderly. J Nutr Health Aging. 2017;21(2):173–9. https://doi.org/10.1007/s12603-016-0733-y.
49. Yuwen P, Chen W, Lv H, Feng C, Li Y, Zhang T, et al. Albumin and surgical site infection risk in orthopaedics: a meta-analysis. BMC Surg. 2017;17(1):7. https://doi.org/10.1186/s12893-016-0186-6.
50. Imaoka M, Higuchi Y, Todo E, Kitagwa T, Ueda T. Low-frequency exercise and vitamin D supplementation reduce falls among institutionalized frail elderly. Int J Gerontol. 2016;10(4):202–6. https://doi.org/10.1016/j.ijge.2016.02.005.
51. Fischer V, Haffner-Luntzer M, Amling M, Ignatius A. Calcium and vitamin D in bone fracture healing and post-traumatic bone turnover. Eur Cell Mater. 2018;35:365–85. https://doi.org/10.22203/eCM.v035a25.
52.• He Y, Xiao J, Shi Z, He J, Li T. Supplementation of enteral nutritional powder decreases surgical site infection, prosthetic joint infection, and readmission after hip arthroplasty in geriatric femoral neck fracture with hypoalbuminemia. J Orthop Surg Res. 2019;14(1):292. https://doi.org/10.1186/s13018-019-1343-2 **This retrospective cohort study reports that nearly half of elderly patients are often malnourished, indicated by serum albumin, prior to hip arthroplasty. Patients with hypoalbuminemia who receive oral nutrition supplementation had reduced wound effusion, periprosthetic joint and surgical site infection, and 30-day readmission rates. The article emphasizes the importance of addressing hypoalbuminemia with enteral nutrition powder to reduce the risk of poor outcomes following hip arthroplasty in elderly patients.**

53. Navarro DA, Boaz M, Krause I, Elis A, Chernov K, Giabra M, et al. Improved meal presentation increases food intake and decreases readmission rate in hospitalized patients. Clin Nutr. 2016;35(5):1153–8. https://doi.org/10.1016/j.clnu.2015.09.012.
54. Torbergsen AC, Watne LO, Frihagen F, Wyller TB, Mowè M. Effects of nutritional intervention upon bone turnover in elderly hip fracture patients. Randomized controlled trial. Clin Nutr ESPEN. 2019;29:52–8. https://doi.org/10.1016/j.clnesp.2017.11.012.
55. Lei M, Hua LM, Wang DW. The effect of probiotic treatment on elderly patients with distal radius fracture: a prospective double-blind, placebo-controlled randomised clinical trial. Benefic Microbes. 2016;7(5):631–7. https://doi.org/10.3920/BM2016.0067.
56. Nordström P, Thorngren KG, Hommel A, Ziden L, Anttila S. Effects of geriatric team rehabilitation after hip fracture: meta-analysis of randomized controlled trials. J Am Med Dir Assoc. 2018;19(10):840–5. https://doi.org/10.1016/j.jamda.2018.05.008.
57. Dyer SM, Crotty M, Fairhall N, et al. A critical review of the long-term disability outcomes following hip fracture. BMC Geriatr. 2016;16(1):158. https://doi.org/10.1186/s12877-016-0332-0.
58. Bogoch ER, Elliot-Gibson V, Beaton D, Sale J, Josse RG. Fracture prevention in the Orthopaedic environment: outcomes of a coordinator-based fracture liaison service. J Bone Joint Surg Am. 2017;99(10):820–31. https://doi.org/10.2106/JBJS.16.01042.
59.• Switzer JA, Schroder LK. Mobile outreach: an innovative program for older orthopedic patients in care facilities. Geriatr Orthop Surg Rehabil. 2019;10:2151459319826476. https://doi.org/10.1177/2151459319826476 **This study demonstrated the feasibility of an outreach program to provide appropriate and coordinated geriatric orthopedic care to patients living in long-term care facilities.**
60. Siris ES, Adler R, Bilezikian J, Bolognese M, Dawson-Hughes B, Favus MJ, et al. The clinical diagnosis of osteoporosis: a position statement from the National Bone Health Alliance Working Group. Osteoporos Int. 2014;25(5):1439–43. https://doi.org/10.1007/s00198-014-2655-z.
61. Trevisan C, Crippa A, Ek S, et al. Nutritional Status, Body Mass Index, and the Risk of Falls in Community Dwelling Older Adults: A Systematic Review and Meta-Analysis. J Am Med Dir Assoc. 2019;20(5):569–582.e7. https://doi.org/10.1016/j.jamda.2018.10.027.
62. Karres J, Kieviet N, Eerenberg JP, Vrouenraets BC. Predicting early mortality after hip fracture surgery: the hip fracture estimator of mortality Amsterdam. J Orthop Trauma. 2018;32(1):27–33. https://doi.org/10.1097/BOT.0000000000001025.
63. Aldebeyan S, Nooh A, Aoude A, Weber MH, Harvey EJ. Hypoalbuminaemia-a marker of malnutrition and predictor of post-operative complications and mortality after hip fractures. Injury. 2017;48(2):436–40. https://doi.org/10.1016/j.injury.2016.12.016.
64. Farmer RP, Herbert B, Cuellar DO, Hao J, Stahel PF, Yasui R, et al. Osteoporosis and the orthopaedic surgeon: basic concepts for successful co-management of patients' bone health. Int Orthop. 2014;38(8):1731–8. https://doi.org/10.1007/s00264-014-2317-y.
65. Barsony J, Kleess L, Verbalis JG. Hyponatremia is linked to bone loss, osteoporosis, fragility and bone fractures. Disord Fluid Electrolyte Metabol. 2019;52:49–60. Karger Publishers. https://doi.org/10.1159/000493237.
66. Chung M, Lee J, Terasawa T, Lau J, Trikalinos TA. Vitamin D with or without calcium supplementation for prevention of cancer and fractures: an updated meta-analysis for the U.S. preventive services task force. Ann Intern Med. 2011;155(12):827–38. https://doi.org/10.7326/0003-4819-155-12-201112200-00005.
67. Haentjens P, Autier P, Collins J, Velkeniers B, Vanderschueren D, Boonen S. Colles fracture, spine fracture, and subsequent risk of hip fracture in men and women: a meta-analysis. J Bone Joint Surg. 2003;85(10):1936–43. https://doi.org/10.2106/00004623-200310000-00011.
68. Conley RB, Adib G, Adler RA, Åkesson KE, Alexander IM, Amenta KC, et al. Secondary fracture prevention: consensus clinical recommendations from a multistakeholder coalition. J Bone Miner Res. 2019;35(1):36–52. https://doi.org/10.1002/jbmr.3877.
69. Hak DJ. The biology of fracture healing in osteoporosis and in the presence of anti-osteoporotic drugs. Injury. 2018;49(8):1461–5. https://doi.org/10.1016/j.injury.2018.04.016.
70. Kates SL, Ackert-Bicknell CL. How do bisphosphonates affect fracture healing? Injury. 2016;47(1):65–8. https://doi.org/10.1016/S0020-1383(16)30015-8.
71. Aydoğan NH, Özel I, Iltar S, et al. The effect of vitamin D and bisphosphonate on fracture healing: an experimental study. JCOT. 2016;7(2):90–4. https://doi.org/10.1016/j.jcot.2016.01.003.