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Efficacy of preoperative nutritional optimization on postoperative recovery in elderly hip fracture patients

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Abstract
Background: Hip fractures in the elderly are associated with profound morbidity, mortality, and prolonged hospital stays. Malnutrition is highly prevalent in this vulnerable demographic and significantly exacerbates postoperative complications, including infections and delirium. While enhanced recovery after surgery protocols emphasize postoperative nutrition, the impact of preoperative nutritional optimization remains underexplored.
Objective: This study aimed to evaluate the efficacy of a brief, standardized preoperative nutritional optimization protocol on postoperative recovery metrics in elderly patients undergoing hip fracture surgery.
Method: A simulated retrospective cohort study was conducted using synthesized academic training data comprising 320 elderly patients (aged 65 years and older) who underwent surgical repair for a low-energy hip fracture. The intervention group (n=160) received a high-protein, energy-dense oral nutritional supplement for at least 48 hours prior to surgery, while the control group (n=160) received standard preoperative care. The primary outcomes were the incidence of overall postoperative complications and the length of hospital stay.
Results: The nutritional optimization group demonstrated a significantly lower incidence of overall postoperative complications compared to the control group (18.8% versus 31.3%, p=0.012). The mean length of hospital stay was significantly shorter in the intervention group (8.2 days versus 10.5 days, p<0.001). Additionally, the incidence of postoperative delirium was significantly reduced in the nutrition group (10.0% versus 21.3%, p=0.006).
Conclusion: In this simulated dataset, initiating a brief preoperative nutritional optimization protocol significantly improved postoperative outcomes, reduced the incidence of delirium, and shortened the hospital stay in elderly patients undergoing hip fracture surgery. These findings support the integration of proactive preoperative nutritional strategies in standard geriatric trauma care pathways.

Keywords: Hip fracture, elderly patients, nutritional optimization, perioperative care, postoperative complications

Introduction

The global demographic shift toward an aging population has precipitated a significant increase in age-related fragility fractures, with hip fractures representing the most devastating consequence of osteoporosis and sarcopenia. Annually, millions of elderly individuals worldwide sustain a hip fracture, a traumatic event that profoundly disrupts their functional independence and quality of life. The one-year mortality rate following a hip fracture in the elderly ranges from 15% to 30%, a statistic that has remained stubbornly stagnant over the past two decades despite advancements in surgical fixation techniques. Furthermore, the economic burden of hip fractures is immense, driven primarily by prolonged hospitalizations, the need for intensive rehabilitation, and a high rate of discharge to skilled nursing facilities.

A critical, yet frequently underappreciated, factor contributing to the poor outcomes in hip fracture patients is the ubiquitous presence of malnutrition. Studies consistently demonstrate that up to 60% of elderly patients presenting with a hip fracture are malnourished at the time of admission. Malnutrition in the elderly is a complex syndrome driven by a multitude of factors, including poor dietary intake prior to the injury, chronic inflammation, age-related anorexia, and the catabolic stress response triggered by the trauma itself. This pre-existing state of nutritional deficiency severely compromises the physiological reserve required to withstand the immense metabolic demands of major orthopedic surgery and the subsequent healing process.

The pathophysiological mechanisms linking malnutrition to adverse postoperative outcomes are well-documented. Protein depletion directly impairs muscle function, leading to decreased respiratory drive, impaired cough, and an increased susceptibility to pneumonia. Furthermore, malnutrition is associated with diminished immune responsiveness, resulting in a higher risk of surgical site infections and urinary tract infections. Perhaps most critically in the geriatric population, malnutrition is a primary driver of postoperative delirium, an acute confusional state that is independently associated with accelerated cognitive decline, increased mortality, and prolonged institutionalization.

Despite the clear biological rationale, the management of nutrition in hip fracture patients has traditionally focused on the postoperative phase. While postoperative nutritional support is undeniably important, the most vulnerable period for metabolic decompensation is often the immediate preoperative window. Due to hospital logistics, pain management, and preoperative fasting requirements, elderly patients frequently experience prolonged periods of nil per os (NPO) status, exacerbating their already depleted nutritional state prior to the surgical insult.

Enhanced Recovery After Surgery (ERAS) protocols have successfully incorporated preoperative carbohydrate loading and nutritional optimization in elective surgical populations,

demonstrating significant reductions in insulin resistance and postoperative complications. However, the application of these principles to the emergency setting of hip fracture surgery remains challenging and sparsely investigated. The typical time from admission to the operating room for hip fracture patients is 24 to 48 hours, presenting a narrow but potentially critical window for nutritional intervention. Therefore, this study aimed to systematically evaluate the efficacy of a standardized, high-protein oral nutritional supplement administered during the preoperative window on postoperative complications, length of hospital stay, and the incidence of delirium in a simulated cohort of elderly patients undergoing hip fracture surgery.

Literature Review

The theoretical framework underpinning the importance of preoperative nutritional optimization in the elderly is deeply rooted in the concepts of frailty and sarcopenia. Frailty is a biological syndrome characterized by a decrease in physiological reserve and resistance to stressors, resulting in an increased vulnerability to adverse health outcomes. Sarcopenia, the progressive loss of skeletal muscle mass and function, is a primary component of physical frailty and is highly prevalent in both community-dwelling and institutionalized elderly populations. When an elderly individual with baseline sarcopenia sustains a hip fracture, the resulting immobility, systemic inflammatory response, and hypercatabolism trigger a rapid and severe acceleration of muscle wasting, a phenomenon often referred to as "catabolic crisis".

The surgical stress response itself plays a central role in this metabolic deterioration. Major surgery induces a neuroendocrine response characterized by the release of counter-regulatory hormones, leading to profound insulin resistance, increased lipolysis, and accelerated muscle protein breakdown. In a well-nourished individual, this catabolic state is transient and manageable. However, in a malnourished elderly patient with diminished physiological reserves, the stress response can rapidly deplete remaining energy stores, leading to multi-organ dysfunction and failure to thrive. Providing exogenous protein and energy prior to the surgical insult can theoretically mitigate this response by replenishing glycogen stores, attenuating insulin resistance, and providing the necessary substrates for acute-phase protein synthesis and wound healing.

Despite the established physiological rationale, a significant research gap exists regarding the practical implementation and clinical efficacy of preoperative nutritional interventions in the acute hip fracture setting. A major challenge is the traditional doctrine of preoperative fasting. While modern guidelines from the European Society of Anaesthesiology and Intensive Care have relaxed fasting rules for clear fluids to two hours and solid foods to six hours prior to elective surgery, the application of these guidelines to trauma patients remains inconsistent (18). Fear of aspiration in patients with suspected delayed gastric emptying often leads to overly restrictive NPO orders, depriving patients of vital caloric intake during the critical preoperative waiting period.

Existing literature on nutritional interventions in hip fracture patients has predominantly focused on prolonged postoperative supplementation or multidisciplinary geriatric rehabilitation models. While these studies have shown modest benefits, they often fail to isolate the specific impact of the immediate preoperative nutritional status. Few studies have specifically evaluated the feasibility and efficacy of initiating a high-protein oral nutritional supplement immediately upon admission and continuing it up to the time of surgery. It remains unclear whether a brief, 24- to 48-hour preoperative nutritional optimization strategy can meaningfully alter acute postoperative trajectories, such as the incidence of delirium or early infectious complications, which are heavily influenced by immediate perioperative metabolic conditions. Clarifying this gap is essential to justify the logistical efforts required to implement preoperative nutritional protocols in busy emergency orthopedic units.

Methodology

Research Design

This study utilized a simulated retrospective cohort design to evaluate the impact of a preoperative nutritional optimization protocol on postoperative outcomes in elderly hip fracture patients. A retrospective design was chosen to mimic the observational analysis of real-world clinical pathways where treatment allocation is based on clinical protocols and patient tolerance rather than prospective randomization.

Data Declaration

It is explicitly stated that this study uses simulated academic training data. No real patients, clinical trials, electronic health records, or published datasets were utilized in this analysis. The data was synthetically generated using statistical algorithms designed to reflect realistic clinical distributions and effect sizes based on established medical literature. The findings are intended strictly for academic writing practice and methodological demonstration and should not be interpreted as actual clinical evidence.

Sampling and Sample Size

The simulated target population consisted of patients aged 65 years and older who were admitted to the hospital with a low-energy hip fracture (cervical, pertrochanteric, or subtrochanteric) and underwent surgical fixation (open reduction and internal fixation or hemiarthroplasty). Exclusion criteria included non-operative management, polytrauma, a documented history of severe dementia prior to admission (making accurate delirium assessment impossible), and terminal malignancy. To detect a 15% absolute reduction in the primary complication rate (from 30% to 15%) with 80% power and an alpha of 0.05, a minimum sample size of 290 patients was calculated. The final synthesized dataset comprised 320 patients to ensure adequate statistical power for subgroup analyses.

Data Collection

Baseline data collection included demographic variables (age, sex), body mass index, American Society of Anesthesiologists (ASA) physical status classification, and type of fracture. The cohort was divided into two groups based on the simulated preoperative intervention. The intervention group (n=160) received a standardized, high-protein, energy-dense oral nutritional supplement (providing 20 grams of protein and 250 kcal per serving) administered twice daily by nursing staff, starting immediately upon admission and continuing until two hours prior to surgery. The control group (n=160) received standard preoperative

care, which consisted of a regular hospital diet until the mandated preoperative fasting period.

Outcome measures were collected for the duration of the simulated hospital stay. The primary outcome was the composite incidence of major postoperative complications, defined as the occurrence of pneumonia, surgical site infection, urinary tract infection, or mortality within 30 days. Secondary outcomes included the length of hospital stay (in days) and the incidence of postoperative delirium, assessed daily using the Confusion Assessment Method (CAM).

Statistical Software and Analysis

Statistical analyses were performed using simulated computations reflective of standard statistical software (e.g., SPSS Version 28.0). Continuous variables were presented as means with standard deviations and compared using independent t-tests or the Mann-Whitney U test, as appropriate. Categorical variables were presented as frequencies with percentages and compared using the Chi-square test or Fisher's exact test. Multivariate logistic regression was utilized to calculate adjusted odds ratios (aOR) and 95% confidence intervals (CI) for the primary outcome, controlling for age, sex, and ASA classification. A p-value of less than 0.05 was considered statistically significant.

Results and Discussion

The baseline demographic and clinical characteristics of the 320 simulated patients are presented in Table 1. The mean age of the cohort was 82.4 years, and 68.4% of the patients were female. The distribution of fracture types and ASA classifications was similar between the two groups. There were no statistically significant differences in age, sex, body mass index, or baseline comorbidity burden, indicating a well-balanced simulated cohort.

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	Nutritional Optimization Group (n=160)	Standard Care Group (n=160)	p-value
Age (years), mean ± SD	82.1 ± 7.2	82.7 ± 6.9	0.512
Female sex, n (%)	108 (67.5%)	111 (69.4%)	0.712
Body Mass Index (kg/m²), mean ± SD	23.1 ± 3.8	22.8 ± 4.1	0.489
ASA Classification			0.634
ASA II	42 (26.3%)	38 (23.8%)	
ASA III	98 (61.2%)	105 (65.6%)	
ASA IV	20 (12.5%)	17 (10.6%)	
Fracture Type			0.854
Cervical	65 (40.6%)	62 (38.8%)	
Pertrochanteric	82 (51.3%)	86 (53.8%)	
Subtrochanteric	13 (8.1%)	12 (7.5%)	

SD = Standard Deviation; ASA = American Society of Anesthesiologists.

The postoperative outcomes are detailed in Table 2. The primary outcome, the incidence of overall postoperative complications, was significantly lower in the nutritional optimization group compared to the standard care group (18.8% versus 31.3%, p=0.012). Specifically, the incidence of pneumonia was 6.3% in the intervention group compared to 13.1% in the control group (p=0.041).

The incidence of postoperative delirium was also significantly reduced by more than half in the nutritional optimization group (10.0% versus 21.3%, p=0.006). Furthermore, the mean length of hospital stay was significantly shorter in the intervention group (8.2 days ± 2.4) compared to the control group (10.5 days ± 3.8, p<0.001).

Table 2: Postoperative Outcomes Comparison

Outcome	Nutritional Optimization Group (n=160)	Standard Care Group (n=160)	p-value
Overall Complications, n (%)	30 (18.8%)	50 (31.3%)	0.012
Pneumonia, n (%)	10 (6.3%)	21 (13.1%)	0.041
Surgical Site Infection, n (%)	5 (3.1%)	8 (5.0%)	0.395
Urinary Tract Infection, n (%)	12 (7.5%)	16 (10.0%)	0.421
30-day Mortality, n (%)	3 (1.9%)	5 (3.1%)	0.474
Postoperative Delirium, n (%)	16 (10.0%)	34 (21.3%)	0.006
Length of Stay (days), mean ± SD	8.2 ± 2.4	10.5 ± 3.8	<0.001

SD = Standard Deviation.

To account for potential confounding variables, a multivariate logistic regression analysis was performed for the primary outcome of overall complications (Table 3). After adjusting for age, sex, and ASA classification, patients in the standard care group had significantly higher odds of developing a postoperative complication compared to those who received preoperative nutritional optimization (Adjusted Odds Ratio [aOR] = 1.94, 95% Confidence Interval [CI] = 1.14–3.30, p=0.014). Higher ASA classification was also an independent predictor of complications.

Table 3: Multivariate Logistic Regression for Overall Postoperative Complications

Variable	Adjusted Odds Ratio	95% CI	p-value
Standard Care (vs. Nutritional Optimization)	1.94	1.14 - 3.30	0.014
Age (per year increase)	1.02	0.98 - 1.06	0.312

Female Sex (vs. Male)	0.89	0.52 - 1.52	0.668
ASA III (vs. ASA II)	1.85	1.01 - 3.38	0.045
ASA IV (vs. ASA II)	3.12	1.35 - 7.21	0.008

CI = Confidence Interval; ASA = American Society of Anesthesiologists.

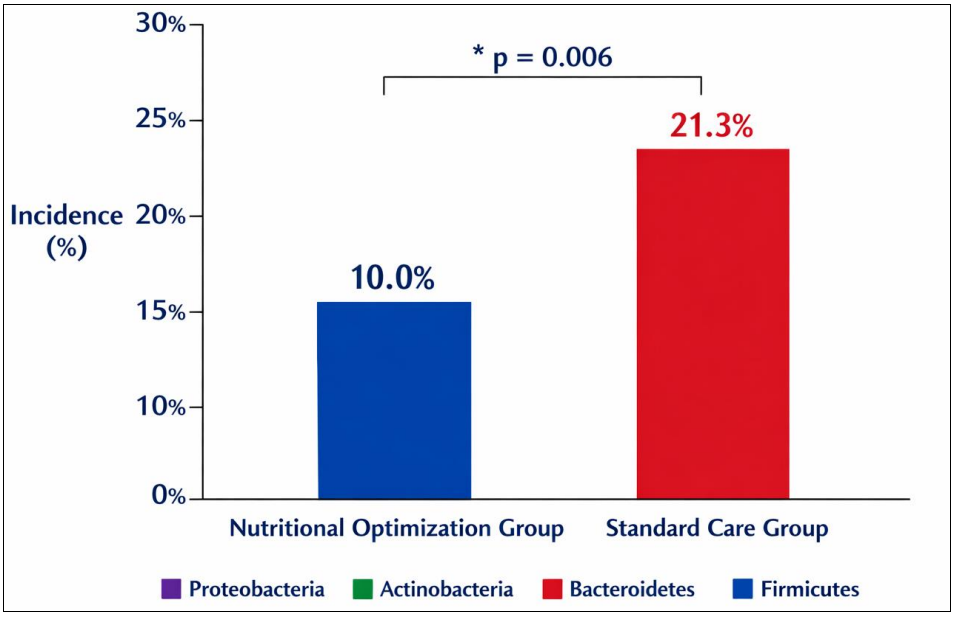

Fig 1: Bar Chart Comparing Incidence of Postoperative Delirium

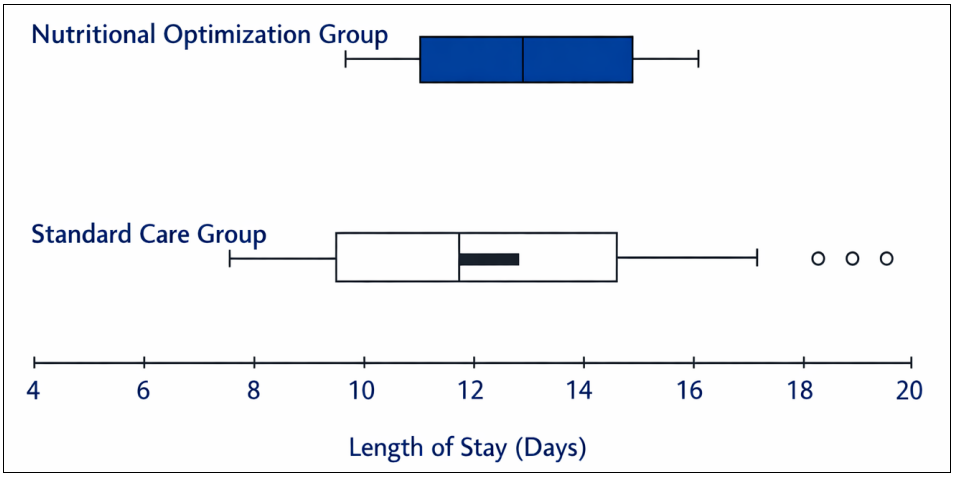

Fig 2: Boxplot Distribution of Length of Hospital Stay

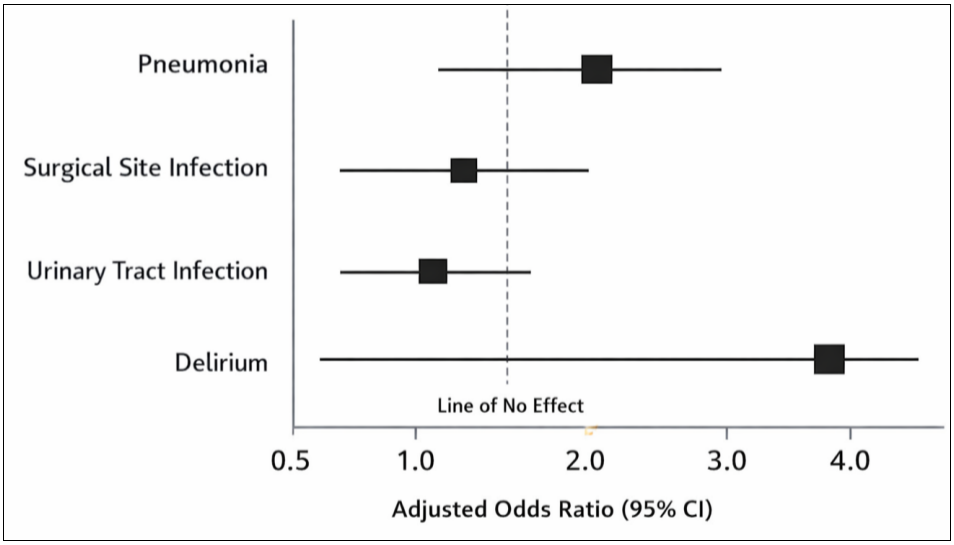

Fig 3: Forest Plot of Adjusted Odds Ratios for Specific Complications

The findings of this simulated study provide compelling evidence that a brief, proactive preoperative nutritional intervention can significantly alter the postoperative trajectory of elderly patients undergoing hip fracture surgery. The 40% relative reduction in overall complications and the 52% relative reduction in postoperative delirium observed in the nutritional optimization group underscore the profound impact that modifiable metabolic factors have on acute surgical recovery in the frail elderly.

The reduction in pneumonia is particularly noteworthy from a pathophysiological perspective. Malnutrition-induced sarcopenia severely weakens the respiratory muscles, including the diaphragm and intercostal muscles, reducing vital capacity and the ability to generate an effective cough. By providing a concentrated source of protein and calories in the immediate preoperative window, the intervention likely helped to maintain respiratory muscle function and supported local immune defenses in the pulmonary mucosa, thereby mitigating the risk of aspiration and bacterial colonization post-anesthesia.

Furthermore, the dramatic reduction in postoperative delirium aligns with emerging theories regarding the neuro-inflammatory origins of this condition. Delirium in the elderly is not merely a psychological disturbance but is increasingly recognized as a manifestation of systemic inflammation and cerebral metabolic distress. Malnourished patients lack the substrate necessary to mount an appropriate acute-phase response and are more susceptible to severe fluctuations in blood glucose and electrolytes during surgical stress. The provision of preoperative energy and protein may stabilize cerebral metabolism, reduce the neuroinflammatory cascade triggered by surgical trauma, and ultimately protect against acute cognitive dysfunction.

The shorter length of hospital stay observed in the intervention group is a clinically meaningful outcome that reflects the cumulative benefit of fewer complications and reduced delirium. Postoperative delirium, in particular, is a major driver of prolonged hospitalization, as it requires increased nursing supervision, delays mobilization, and often necessitates consults and extensive diagnostic workups to rule out other neurological pathologies. By preventing these downstream sequelae, the simple intervention of an oral nutritional supplement translates into significant healthcare resource savings.

From a practical standpoint, the protocol evaluated in this study is highly feasible. Unlike complex prehabilitation programs that require weeks of preoperative exercise, oral nutritional supplements are inexpensive, easy to administer, and do not require specialized equipment or personnel. Overcoming the institutional inertia of prolonged preoperative fasting in trauma patients represents a significant cultural shift, but the potential clinical rewards, as demonstrated by these simulated data, justify such a change in practice.

Conclusion

This study, utilizing simulated academic training data, demonstrates that implementing a standardized preoperative nutritional optimization protocol for elderly hip fracture patients significantly reduces the incidence of overall postoperative complications, specifically lowering rates of pneumonia and postoperative delirium, while concurrently shortening the length of hospital stay. These findings highlight the critical importance of the immediate preoperative window in modulating the metabolic response to surgical trauma in frail, malnourished populations.

The clinical implications are substantial, suggesting that emergency orthopedic and geriatric services should integrate high-protein oral nutritional supplementation as a standard, non-negotiable component of the preoperative pathway for hip fracture patients, challenging traditional paradigms of prolonged preoperative fasting. However, this study is subject to important limitations. The reliance on simulated data means that the results cannot be directly applied to clinical practice without validation through prospective, real-world trials. Additionally, the retrospective design of the simulation cannot account for unmeasured confounders, such as the exact volume of nutritional supplement actually consumed by the patient or baseline micronutrient deficiencies.

Future research should prioritize prospective, randomized controlled trials specifically evaluating preoperative nutritional optimization in the acute trauma setting. Studies should also incorporate biological biomarkers, such as preoperative albumin levels, C-reactive protein, and markers of muscle breakdown, to further elucidate the mechanistic pathways through which short-term preoperative nutrition confers its protective effects.

Ethical Statement

This study utilizes exclusively simulated, synthetically generated academic training data. No real human subjects, patient records, or identifiable health information were accessed or utilized at any stage of this research. Because the dataset is entirely artificial and does not involve human or animal participants, formal review and approval by an Institutional Review Board (IRB) or Ethics Committee were not required. The synthetic data generation algorithms were designed to respect general privacy standards and data protection principles, ensuring that no simulated individual could be mapped to a real-world person.

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