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Comorbidity burden and nutritional status are associated with short-term improvement in functional independence and pain intensity after hip fracture surgery in older adults with in-hospital rehabilitation

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ABSTRACT

Purpose: Hip fracture is a common condition among older adults. The aim of this study was to explore the influence of nutritional status and comorbidity burden on changes in functionality, fall risk, and pain intensity one month after hip surgery in older adults with in-hospital rehabilitation.

Methods: Thirty-six hip fracture patients (55.6% female) aged 65 years or older with indication for surgical resolution were recruited. The main outcomes were functional independence (Barthel Index), risk of falls (Downton Falls Risk Index) and pain intensity (Visual Analogue Scale), assessed preoperatively and one month after discharge. Covariates included age, sex, BMI, Charlson Comorbidity Index (CCI) and nutritional status (Mini Nutritional Assessment). For the inferential analysis, a one-way analysis of covariance (ANCOVA) was applied.

Results: Significant improvements were observed in functional independence (11.0 points, 95% CI: 1.7 to 20.3), risk of falls (-2.8 points, 95% CI: -4.0 to -1.7) and pain intensity (-2.6 points, 95% CI: -3.4 to -1.9). Among the covariates, a significant interaction was found between the CCI and improvements in functional independence (F=7.03, p=0.010, η^2p=0.093), while nutritional status showed a significant interaction with pain reduction (F=5.65, p=0.020, η^2p=0.075).

Conclusion: A lower comorbidity burden was associated with greater postoperative functional independence, while better nutritional status was associated with a greater reduction in postoperative pain intensity.

Introduction

Hip fracture is a common condition among older adults, especially in women. The worldwide number of hip fractures is expected to increase from 1.26 million in 1990 to 4.5 million in 2050[1], with enormous costs due to the long period of hospitalization and subsequent rehabilitation. For example, the annual cost of treatment in the European Union can reach 32 billion euros[2]. Critical consequences of hip fracture include delirium[3], postoperative infection (e.g., pneumonia)[4], depression and disability[1], institutionalization[5], and mortality[2]. Pain is also another common postoperative complication in older adults, which may be present for months after hip fracture surgery and is associated with poor lower extremity function[6]. Postoperative pain also impacts the quality of life of older people with hip fractures during the 12 months following hospital discharge[7], justifying the need for pain mitigation strategies during the first month after surgery. In this sense, it is crucial to identify the determinants of postoperative pain in order to implement early strategies and impact on the functionality.

Older adults with low nutritional reserves have limited immune system function, which increases the risk of perioperative complications[8]. Poor nutritional status may play an important role in the

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onset, development and prognosis of chronic pain. This link could be explained by numerous potential underlying mechanisms, including oxidative stress, inflammation and glucose metabolism[9]. In fact, nutritional status, assessed with the Mini Nutritional Assessment (MNA), may be key to better predict gait status and mortality six months after hip fracture[10]. Nutritional status is also a risk factor for future osteoporotic refracture[11]. Although physicians often request albumin as a quick assessment of nutritional status, MNA can provide a more comprehensive assessment of hospitalized older adults, taking into account not only physical and dietary aspects, but also psychological and functional factors that may influence nutrition[12]. Nevertheless, the relationship of this variable with postoperative pain after hip fracture in older adults is unknown.

The Charlson Comorbidity Index (CCI) is a reliable and simple tool for risk stratifying patients according to comorbidities[13]. It has been shown to be a significant predictor of mortality after hip fracture surgery[14]. However, its relationship to changes in functional independence after hip surgery in older adults has been studied in only a few studies. For example, a previous study found that CCI, along with hip fracture surgical treatment and pre-fracture pain intensity, was one of the predictors of a hip fracture patient's ability to return to pre-fracture ambulatory status within 1 year[15]. Following hip fracture surgery, there may be a limitation of activity levels and loss of functional independence [1]. In this regard, a higher score on the Barthel index, a useful tool for the assessment of activities of daily living and functional recovery, was independently associated with lower one-year mortality of geriatric patients after hip fracture surgery[16], providing essential prognostic information for early rehabilitation planning. A higher Barthel Index score at discharge and a longer hospital stay are also predictors of discharge to home, rather than institutionalization[17].

Given that early rehabilitation intervention is present in several clinical recommendations from scientific societies[18], it is necessary to understand which clinical factors determine short-term postoperative outcomes. This is particularly relevant given that most hip surgeries are performed on older adults whose functionality is often compromised, leading to an increased risk of falls and significant nutritional deficiencies that may impact postoperative outcomes. In this regard, the CCI and the MNA score, which measure disease burden and nutritional status respectively, are two simple and quick tools for hospital screening and clinical decision making, for example, to optimize early rehabilitation resources after hip surgery. This study aims to explore the influence of nutritional status and comorbidity burden on changes in functionality, fall risk, and pain intensity one month after hip surgery in older adults with in-hospital rehabilitation. At the same time, we aimed to study the demographic (age, sex and body mass index [BMI]) that are related to changes in the main outcomes.

Methods

Participants and design

This prospective study recruited 36 patients with hip fractures who were routinely admitted to the Hospital Clínico de la Universidad de Valencia from July 2022 to March 2023. The Hospital Clínico de la Universidad de Valencia, in Spain, is an academic and health center of reference, specialized in research and advanced medical training, providing high quality health care. Inclusion criteria were as follows: i) diagnosis of femoral neck fracture or intertrochanteric fracture; ii) age 65 and over; iii) indication for surgical resolution of the fracture, including internal fixation (e.g., DHS or cephalomedullary nailing) or hip arthroplasty; and iv) ability to follow instructions and agree to participate voluntarily in the study. Exclusion criteria were as follows: i) hip fracture identified as a pathologic fracture (i.e., bone metastases, osteoporosis, Paget's disease, osteomyelitis); ii) complex fracture (unstable posteroexternal/posterointernal fragment or comminuted unstable); iii) history of cancer or infection currently or within the last year; iv) severe cognitive impairment (i.e.,>7 points on the Short Portable Mental Status Questionnaire [SPMSQ])[19]; v) trauma to another body region. The sample size was pragmatic and depended on staff capacity and patient volunteers. The study, which collects clinical data routinely stored in each patient's medical record, was approved by a local committee and follows the principles of the Declaration of Helsinki. In addition, patients signed an informed consent form prior to surgery. In accordance with local legislation, it was ensured that participants were not influenced by analgesics and/or anesthesia.

Procedures

The surgery was performed by several surgeons, who followed a protocol previously standardized by the hospital's trauma service. All surgeries were performed through a direct anterolateral or lateral approach with regional anesthesia. No drains were used. During the perioperative period, nausea was treated prophylactically. After surgery, patients were transferred to the Intermediate Care Unit, where multimodal analgesia was continued with opioid sparing and aggressive intravenous and oral fluid loading. Postoperative radiographs and hematocrit/hemoglobin testing were performed during hospitalization. Discharge criteria to home were as follows: mild to moderate pain (VAS<7), absence of nausea or orthostatic symptoms, and hemoglobin ≥7 mg/dL. At discharge, oral analgesia was prescribed with paracetamol 1 g, 3 times/day for 10 days and injectable heparin (1 time/day) for 10 days.

Patients received a daily visit from the physiotherapist starting 24 hours after surgery. The exercise protocol included 1) Active-assisted hip, knee and ankle flexion mobilization starting with 10-15 repetitions and progressing up to 30 repetitions according to tolerance; 2) Isometric contractions (5 seconds) of quadriceps and gluteus maximus with 10-15 repetitions and progressing up to 30 repetitions according to tolerance; 3) If orthostatic intolerance was not evident, patients sat down and stood up and a partial reduction of weight bearing gait was performed with the aid of a walker or two crutches (progressing from 2 to 10 minutes. Subsequent sessions included open chain exercises for quadriceps, gluteus medius and gluteus maximus, emphasizing concentric and eccentric phases (5 seconds total) with 10-15 repetitions and progressing up to 30 repetitions according to tolerance. If necessary, stair training was included. A safe pain threshold of 5/10 on the visual analog scale was established for all exercises. At discharge, patients were given printed material with the exercises to continue performing them at home. All patients were scheduled for a follow-up appointment one month after discharge.

Main outcomes

The dependent variables (outcomes) included were: i) Barthel index: Activities of daily living and functional independence were assessed with the Barthel index, which consists of 10 items: feeding, bathing, personal hygiene, dressing, sphincter control, toilet use, transfers (from bed to chair and vice versa), mobility on flat surfaces and stairs. The total score ranges from 0 to 100 points with a fixed interval of 5 points. A higher score indicates greater functional independence[20]; ii) Falls risk: assessed using the Downton Falls Risk Index (DFRI), which is a composite index of established falls risk factors classified into five domains: known previous falls, medication (use of sedatives, antidepressants, etc.), sensory impairment, mental status (orientation to time, place and person) and gait. Scores for each risk domain are summed to obtain an index (range 0 -11 points).

A score of three or more is considered to indicate a high risk of falls[21]; iii) Pain intensity: assessed using the Visual Analog Scale (VAS), in which participants were asked to rate their pain on a defined scale of 0 to 10 points, where 0 is "no pain" and 10 is "worst pain imaginable"[22]. These variables were measured preoperatively and one month after surgery by a physical therapist with more than ten years of clinical experience.

Covariates

Demographic variables were age, sex, BMI, type of surgery (internal fixation or hip arthroplasty) and comorbidities were obtained from the hospital medical record. In addition, the total length of hospital stay was recorded. Nutritional status was assessed using the MNA questionnaire[23], which includes 18 items related to nutritional status, such as anthropometric (BMI, calf and forearm circumference), general assessment (medication, acute illness, psychological problems and mobility), dietary assessment (fluid intake, number of daily meals and composition of food intake). The maximum score is 30 points. A higher score represents a better nutritional status[23].

On the other hand, the following information was used to obtain the CCI score: the age-based score initiates at 50 years (+1 point for every 10 years); history of definite or probable myocardial infarction (+1 point); congestive heart failure (+1 point); peripheral vascular disease (+1 point); cerebrovascular disease (+1 point); dementia (+1 point); chronic obstructive pulmonary disease (+1 point); connective tissue disease (+1 point); peptic ulcer disease (+1 point); liver disease (mild, +1 point; moderate to severe, +3 points); diabetes mellitus (+1 point); hemiplegia (+2 point); moderate to severe chronic kidney disease (+2 point); solid tumour (localised, +2 point; metastatic, +6 point); leukaemia (+2 point); malignant lymphoma (+2 point); and acquired immune deficiency syndrome (+6 point)[13]. A higher CCI score indicates a higher risk of one-year mortality given a higher comorbidity burden.

Statistical analysis

Normality of quantitative variables was tested using the Shapiro-Wilk test. To describe the baseline characteristics of the population, categorical variables were reported by percentage frequency distribution and quantitative variables were reported by mean with standard deviation or median with interquartile range, depending on whether the variable is normally distributed. For the inferential analysis, a one-way analysis of covariance (ANCOVA) was applied (two-time categories: pre- and post-evaluation). Then, age, sex, BMI, CCI score and MNA score were entered as covariates in each model (i.e., for each of the dependent variables: Barthel index, falls risk, and pain intensity). In the case of a significant interaction, simple correlations between the significant covariate and the mean (pre-post) difference of the dependent variables were applied to determine the effect size. Correlations were interpreted as very weak <0.20, weak 0.20-0.39, moderate 0.40-0.59, strong 0.60-0.79 and very strong 0.80-1.0. Additionally, the partial eta squared values (η^2p) were defined as small (> 0.01), medium (> 0.06) and large (> 0.14). A p-value of 0.05 was set for statistical significance. All statistical analyses were performed with Jamovi v.2.3.28 software (R Core Team 2021)[24].

Results

Thirty-six participants (55.6% women) were included, with an average age of 76.1 (SD: 4.6) years. The baseline characteristics of the sample are described in Table 1. No dropouts during follow-up.

One-way analysis of variance without covariates showed a significant improvement in functional independence (F=5.53, p=0.022, η^2p=0.073), risk of falls (F=23.5, p<0.001, η^2p=0.251) and pain intensity (F=48.56, p<0.001, η^2p=0.410). The main results are presented in Table 2. Improvements in the Barthel index were 11 points [95% CI: 1.7 to 20.3], while the DFRI decreased by -2.8 [95% CI: -4.0 to -1.7] and the VAS by -2.6 points [95% CI: -3.4 to -1.9].

Table 1
Baseline characteristics

Characteristics	value
N	36
Age (years)	76.1 (4.6)
Sex (%)	
Man	44.4%
Woman	55.6%
BMI (kg/m^2)	29.0 (27.0 - 32.0)
CCI (points)	3.5 (3.0 - 4.0)
Hospital stay (days)	5.0 (3.0 - 7.0)
Type of surgery (%)	
Internal fixation	55.6%
Hip arthroplasty	44.4%

Data presented as mean (standard deviation), median (interquartile range) or percentages (%).
Abbreviations: BMI, body mass index; CCI, Charlson comorbidity index

Among the covariates, a significant interaction (i.e., significant covariate effect) was found between the CCI and improvements (pre-post change) in Barthel index (F=7.03, p=0.01, η^2p=0.093), while nutritional status was the covariate that showed a significant interaction with pain reduction (pre-post change) (F=5.65, p=0.020, η^2p=0.075). No significant interaction was found for the rest of the covariates (p<0.05).

For the correlation analysis, a small significant correlation was observed between CCI and functional independence (Barthel index) one month after hospitalization (Rho Spearman=0.342, p=0.041). A moderate correlation was observed between better nutritional status and a greater reduction in pain intensity one month after hospitalization (Rho Spearman=0.515, p=0.001).

There were no cases with major complications (i.e., infection, in-hospital pneumonia or dislocation) during follow-up.

Discussion

The main results of our study were: i) a significant correlation between lower comorbidity burden and greater postoperative functional independence. ii) a better nutritional status was associated with a greater reduction in postoperative pain intensity. In this sense, the CCI and the MNA score are two simple and quick tools for hospital screening and clinical decision-making, e.g., for optimizing early rehabilitation resources after hip surgery.

The correlation observed between the comorbidity index scores and the postoperative Barthel index underlines the critical role of functionality in the recovery of older adults. These results are consistent with those of a previous study, according to which CCI was one of the predictors of a hip fracture patient's ability to return to pre-fracture ambulatory status within 1 year, along with hip fracture surgical treatment and pre-fracture pain intensity[15]. Moreover, these results are in line with a previous study which found that the CCI may be a useful tool for identifying patients with poorer functional performance (i.e. shorter distance covered in the six-meter walk test) after prolonged hospitalization for COVID-19[25]. Similarly, in older adults with chronic low back pain, the number of comorbidities at baseline can predict pain and disability at 6 and 12 months[26]. According to the literature, the minimum clinically important difference (MCID) of the Barthel index at 12 months was 9.8 points in elderly patients who underwent hemiarthroplasty after femoral neck fracture[27]. In this regard, our results found a greater increase in MCID only one month after hospital discharge (i.e., 11 points). These results may be relevant when planning for a smoother and more effective

Table 2
Main findings (n=36)

Outcomes	Pre[a]	Post[a]	Mean difference [95% CI]	d Cohen	p-value
Barthel index (0-100)	71.4 (22.1)	82.4 (17.3)	11.0 [1.7 to 20.3]	0.55	0.022
DFRI (0-11)	4.1 (3.2)	1.3 (1.3)	-2.8 [-4.0 to -1.7]	1.14	<0.001
VAS (0-10)	4.1 (1.9)	1.4 (1.2)	-2.6 [-3.4 to -1.9]	1.64	<0.001

[a] data presented as mean (standard deviation).Effect size values (d Cohen) of 0.2, 0.5 and 0.8 were interpreted as small, moderate and large, respectively.Abbreviations: DFRI, Downton Falls Risk Index; VAS, Visual Analog Scale.

recovery, which minimizes the need for prolonged medical care[28,29]. Importantly, a higher Barthel Index score at discharge and a longer hospital stay are predictors of discharge to home, avoiding institutionalization[17]. Obtaining a higher Barthel index score in the short term may be key to decreasing the 1-year mortality of geriatric patients after hip fracture surgery[16], reinforcing the need to provide early and sufficient comprehensive rehabilitation to achieve better functional independence.

The change in postoperative pain was also higher than the MCID, set at 2 points on the VAS[30]. Thus, nutritional status was a novel and interesting factor related to pain responses after hip surgery. Our findings underscore the importance of considering nutritional well-being as an influential factor in shaping older adults' experiences of pain after surgery. Previous research suggests that poor nutritional status may play an important role in the onset, development and prognosis of chronic pain, a relationship moderated by many potential underlying mechanisms such as oxidative stress, inflammation and glucose metabolism [9]. Malnutrition is an area of concern, especially given that it is a modifiable risk factor[31]. Our results reinforce the relevance of identifying malnutrition, which will help to provide better care for patients, for example by integrating nutritional therapy into the standard care of older adults with hip fractures. In fact, nutritional assessment can even predict gait status and mortality after hip fracture[10]. Thus, early nutritional interventions (nutritional education, dietary consultation for food selection and prescription of nutritional supplements) are important for recovery during rehabilitation from a fall-related fracture[32]. This novel finding adds depth to the prevailing understanding of the intricate interplay between physiological conditions and pain perception. This finding prompts a reevaluation of existing clinical approaches, emphasizing the need for tailored nutritional interventions as a potential avenue for optimizing pain management strategies following hip surgery. Future studies should further investigate the mechanisms by which good nutrition may act as a protective factor in the prevention of persistent pain after surgery.

These experiences highlight the importance of early and comprehensive approaches in managing hip fractures, particularly in older adults. For example, physical and nutritional interventions have shown positive results in costs and administrative requirements of inpatient care pathways, including indirect costs due to license leaving and reduction of income opportunities[6,10,28]. On the other hand, functionality improvements have shown impacts related to clinical incomes (i.e., re-hospitalizations, requirements of follow-up process, among others) and body-functions dimensions (fall risk, re-fracture or comorbidities, complications, among others)[2,17]. These types of approaches could be incorporated in designing and implementing care pathways related to hip fracture, improving resolutive and efficiencies capabilities of institutions[16,33,34].

Improvements in functionality, risk of falls and pain could be a protective factor in the long-term care of older adults after surgical interventions. Previous studies have established that functionality is related to improvements in physical and psychological variables, and especially explain mortality and morbidity in aging[35,36]. Also, postoperative pain influences the long-term quality of life of older people with hip fracture [7]. According to a life-course approach, improvements in short-term physical and psychological conditions may reduce the susceptibility of older people to require rehabilitation or medical care or may increase participation in recreational activities offered by the community[35,36]. Thus, consistent access to rehabilitation could protect life trajectories from limited access to health care, reduced quality of life, and isolation.

Limitations

Our results should be interpreted taking into account the following limitations. First, the single-center design of the observational study does not allow a cause-effect relationship to be established between an intervention and the outcomes measured and limits the generalizability of the results. Second, long-term follow-up is not available to assess whether the observed improvements were sustained over time. Third, given that the sample size was small, it was not possible to perform subgroup analyses based on factors such as age group, sex or type of hip fracture to explore possible differences in outcomes within the study population. In addition, we had no information on pre-existing nutritional deficiencies prior to hospitalization. Fourthly, after discharge, all patients received the same exercise regimen at home and were scheduled to start rehabilitation in hospital after one month. However, it was not recorded whether patients received any additional therapy at home, which could have influenced the results. It was also not recorded whether participants took additional analgesics to those initially prescribed after discharge. Finally, the influence of psychosocial variables (e.g., kinesiophobia, catastrophizing, self-efficacy, mental health) that have shown a significant association with pain and function were not studied; therefore, future studies should consider these aspects for the prognosis of hip surgery patients.

Conclusion

One month after hospital discharge, significant improvements in functional independence, fall risk and pain intensity were observed in older adults who underwent hip surgery with in-hospital rehabilitation. A lower comorbidity burden was associated with greater postoperative functional independence, while better nutritional status was associated with a greater reduction in postoperative pain intensity. In this regard, the Charlson Comorbidity Index and the Mini Nutritional Assessment score are two simple and quick tools for hospital screening, predicting postoperative outcomes and optimizing early rehabilitation resources after hip surgery.

Implications for rehabilitation

- Rehabilitation teams should consider comorbidity burden when planning early rehabilitation of older adults undergoing hip surgery.
- Improving the nutritional status of older adults awaiting hip surgery could reduce the risk of postoperative pain.

- The Charlson Comorbidity Index and Mini Nutritional Assessment score are two simple and quick tools for hospital screening and clinical decision making.

Declaration of competing interest

None.

CRediT authorship contribution statement

Rodrigo Núñez-Cortés: Writing – original draft, Conceptualization, Formal analysis. **Laura López-Bueno:** Project administration, Data curation, Conceptualization, Writing – review & editing. **Álvaro Besoain-Saldaña:** Writing – review & editing. **Carlos Cruz-Montecinos:** Writing – review & editing. **Lilian Solís-Navarro:** Writing – review & editing. **Luis Suso-Martí:** Writing – review & editing. **Rubén López-Bueno:** Supervision, Writing – review & editing. **Antoni Morral:** Writing – review & editing. **Joaquín Calatayud:** Writing – review & editing, Supervision, Investigation.

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