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# The role of ASA score and Charlson comorbidity index in predicting in-hospital mortality in geriatric hip fracture patients

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**Abstract. – OBJECTIVE:** We aimed to determine the role of American Society of Anesthesiologists (ASA) score and Charlson Comorbidity Index (CCI) in determining in-hospital mortality and other factors associated with mortality in patients over 65 years of age who underwent surgery for hip fracture during our study, including the COVID-19 process.

**PATIENTS AND METHODS:** Between January 1st, 2020, and December 31st, 2021, 200 patients over 65 years of age who underwent hemiarthroplasty or internal fixation for hip fracture after low-energy trauma were retrospectively evaluated.

**RESULTS:** Of the 200 patients included in the study, 130 were female and 70 were male. The median ASA score was 3 (IQR: 2-3), and the median CCI was 3 (IQR: 5-7). Forty-two of 137 (68.5%) patients with intertrochanteric fractures and 22 of 63 (31.5%) patients with femoral neck fractures (34.4%) died. The median time to surgery was 4 days (IQR: 3-6). Among chronic diseases, cardiac pathologies were the most common (57%, n=114). There were statistically significant differences in ASA scores ($p$=0.0001 [z=-5.472]), CCI scores (0.0001 [z=-6.156]), presence of cardiac disease [$p$=0.0001 ($\chi^2$=32.155)] and presence of neurological disease [$p$=0.045 ($\chi^2$=4.007)] compared to mortality. ASA and CCI scores were significantly higher in people with mortality. As a result of the multivariate model established with these factors, which were found to be significant in univariate analyses, only the presence of cardiac disease ($p$=0.0001) and the increase in CCI scores ($p$=0.0001) were found to have a statistically significant increasing effect on mortality.

**CONCLUSIONS:** CCI and cardiac pathology were associated with mortality. The type of hip fracture, surgical method, and anesthesia method were not associated with mortality.

*Key Words:*
Charlson comorbidity index, ASA, Femur fracture, COVID-19.

## Introduction

The risk of life-threatening hip fractures increases significantly with age. Hip fractures are associated with mortality, especially in patients with one or more comorbidities[1,2]. Hip fractures in geriatric patients can cause a significant deficit in basic activities such as dressing, getting out of bed, walking, and going to the toilet. In some patients, it may cause difficulties even in the most basic activities of daily living[3]. The increasing life expectancy and population growth will lead to an increase in the incidence of fractures in the near future. The 30-day mortality rate, which is considered a quality indicator for hospital care in patients with hip fracture, was 13.3%[4]. Therefore, early detection and appropriate management of femur fractures in elderly patients is very important to minimize morbidity and mortality rates.

The American Society of Anesthesiologists (ASA) has developed a classification system to assess the general health status of patients prior to surgery and anesthesia. This classification system, known as the ASA Physical Status Classification System, is widely used by anesthesiologists to assess a patient's fitness for surgery and determine appropriate anesthetic management during the procedure. It is important to note that, rather than predicting surgical or anesthetic risks, the ASA Physical Status Classification System provides a standardized way for anesthetists to communicate a patient's general health status to other healthcare providers involved in the patient's care[5].

The ASA Physical Status Classification System classifies patients into six different classes according to their current health status, including underlying medical conditions that may affect anesthesia. The classifications range from ASA Class I, which indicates a healthy patient with no

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medical problems, to ASA Class VI, which indicates a patient who is brain dead and whose organs have been harvested for donation[6,7]. It was first developed in 1987 by Charlson et al[8]. The Charlson Comorbidity Index (CCI) gives each medical condition, such as heart disease, diabetes, kidney disease, and cancer, a score ranging from 1 to 6 according to its impact on patient mortality. A higher CCI score indicates a higher probability of mortality. The total score is then used to predict patient outcomes and guide treatment decisions[7,8]. The Charlson Comorbidity Index has been shown to be particularly useful in predicting mortality and morbidity in patients undergoing surgical procedures. Patients with higher Charlson Comorbidity Index scores may require more intensive monitoring and treatment. Healthcare professionals should take this into account when creating individual patient treatment plans[9,10].

Knowing the factors associated with mortality in patients with hip fractures is important for more careful preparation and close postoperative follow-up in this patient group. We aimed to determine the role of ASA score and CCI in determining in-hospital mortality and other factors associated with mortality in patients over 65 years of age who underwent surgery for hip fracture during our study, including the COVID-19 process.

## Patients and Methods

Ethical approval for this single-center retrospective study was granted by the Clinical Research Ethics Committee of Balıkesir University Faculty of Medicine on 16 November 2022 (Decision No. 2022/128). Patients over 65 years of age who underwent hemiarthroplasty or internal fixation (proximal femoral nail-Dynamic Hip Screw) for hip fracture after low-energy trauma between January 1st, 2020, and December 31st, 2021, were included in our study. A total number of 200 patients were collected from Balıkesir Atatürk City Hospital. Patients with multiple traumatic injuries, high-energy trauma, and hip fractures resulting from pathological fractures were not included in the study. Age, sex, time from fracture to surgery, total length of stay, ASA score, anesthesia method, fracture type, treatment, comorbidity, Charlson Comorbidity Index, mortality status, fracture details, and operative fixation method were analyzed using the operative notes and patient record system. The choice of fracture fixation was performed at the discretion of the surgeon, depending on the type of fracture and age of the patient. All surgeries were performed by two professionally experienced orthopedic surgeons.

All patients were preoperatively evaluated for comorbidities and graded using the age-adjusted CCI. CCI scores were calculated based on 17 comorbid conditions, and each was assigned a weighting from 1 to 6 according to its impact on mortality. The age-adjusted CCI considers each decade after the age of 40 as one point (Table I). The time to surgery was calculated as the time from admission to the hospital until the start of surgery. For patients referred to us from other hospitals, it was calculated from the first admission to the hospital for the fracture. Anesthetic assessment and ASA were determined by the consultant anesthetist during the surgery. Comorbidities were categorized into the following five groups: cardiovascular, pulmonary, renal, central nervous, and endocrine system diseases (including diabetes mellitus). These five comorbidities were selected as the most important ones based on our experience.

### *Statistical Analysis*

All statistical analyses were performed using SPSS 25.0 [SPSS Statistics 25 software (IBM Corp., Armonk, NY, USA). Continuous variables were defined as the mean ± standard deviation, median (IQR: 25th and 75th percentiles), and minimum-maximum values, and categorical variables were defined by number and percentage. The Kolmogorov-Smirnov test was used for the determination of normal distribution. For independent group comparisons, the Mann-Whitney U test was used when parametric test assumptions were not provided. The Chi-square test was used for categorical variables. Logistic regression analysis was used to determine the risk factors for mortality. Statistical significance was set at $p \leq 0.05$.

## Results

A total of 200 patients over 65 years of age with hip fracture were included in the study. 130 of the patients were female and 70 were male. The median age of the patients was 79 years (IQR: 71.25-88). A total of 139 patients underwent spinal anesthesia. Sixty-one patients who were medically unsuitable for spinal anesthesia or who did not want spinal anesthesia underwent surgery

**Table I.** Charlson Comorbidity Index.

| Score | Condition |
|---|---|
| 1 | For each decade over age 40 years, up to 4 points |
| 1 | Myocardial infarction |
| | Congestive Heart failure |
| | Peripheral vascular disease (includes aortic aneurysm ≥ 6 cm) |
| | Cerebrovascular disease |
| | Dementia |
| | Chronic pulmonary disease |
| | Connective tissue disease |
| | Peptic ulcer disease |
| | Mild liver disease |
| | Diabetes without end-organ damage |
| 2 | Hemiplegia |
| | Moderate or several renal disease |
| | Diabetes with end-organ damage (retinopathy, neuropathy, nephropathy etc.) |
| | Tumor without metastases (exclude if >5 years from diagnosis) |
| | Leukemia (acute or chronic) |
| | Lymphoma |
| 3 | Moderate or several liver disease |
| 6 | Metastatic solid tumor |
| | Acquired immunodeficiency syndrome (AIDS) |

under general anesthesia. The median ASA score was 3 (IQR: 2-3) and was associated with in-hospital mortality ($p$<0.01). Eighteen (9%) patients' ASA score were ASA I, 50 (25%) were ASA II, 94 (50%) were ASA III, and 38 (19%) were ASA IV. The median CCI was 3 (IQR: 5-7), and there was a statistically significant difference with in-hospital mortality ($p$<0.01) (Table II).

Forty-two of the 137 (68.5%) patients with intertrochanteric fractures and 22 (34.4%) of the 63 (31.5%) patients with femoral neck fractures died. Fracture type was not associated with mortality. 116 (58%) patients underwent internal fixation, and 84 (42%) patients underwent hemiarthroplasty. Surgical treatment was not associated with mortality ($p$=0.731) (Table II). The median time to surgery was 4 days (IQR: 3-6). 45 patients underwent surgery within the first 48 hours.

Among the chronic diseases, cardiac pathologies were the most common condition (57%, n=114), followed by diabetes mellitus (34.5%, n=69), neurological diseases (Alzheimer's disease, dementia, SVO) (24%, n=48), pulmonary diseases (18.5%, n=37), and renal failure (16.5%, n=33) (Table II). In our study, diseases such as leukemia, lymphoma, metastatic solid tumors, and AIDS were not detected in the CCI.

There were statistically significant differences in ASA scores [$p$=0.0001 (z=-5.472)], CCI scores [$p$=0.0001 (z=-6.156)], presence of cardiac disease [$p$=0.0001 ($\chi^2$=32.155)], and presence of neurological disease [$p$=0.045 ($\chi^2$=4.007)] according to mortality. ASA and CCI scores were significantly higher in people with mortality. In addition, cardiac disease and neurological disease were found to be significantly higher in patients with mortality. Demographic data and mortality status of the patients are shown in Table II.

As a result of the multivariate model established with these factors, which were significant in univariate analyses, only the presence of cardiac disease ($p$=0.0001) and increase in CCI scores ($p$=0.0001) were found to have a statistically significant increasing effect on mortality. The results of the multivariate analysis are given in Table III.

## Discussion

In hip fracture patients, many parameters such as injury, type of operation, postoperative delirium, timing of rehabilitation, and surgical technique are important determinants of clinical findings related to outcome and mortality. In addition, some preoperative factors, such as advanced age, male sex, poor premorbid functional capacity, and the presence of multiple comorbidities, also affect postoperative mortality[11].

**Table II.** Baseline characteristics of the study population of the dead and alive.

| | | n=200 | Mortality | | p |
|---|---|---|---|---|---|
| | | | Alive (n=136) | Dead (n=64) | |
| Age | Mean±S.D | 79.99 ± 9.01 | 79.89 ± 9.12 | 80.2 ± 8.83 | 0.669 (z=-0.428) |
| | Med (IQR) | 79 (71.25-88) | 79 (71-88.75) | 80 (72-87) | |
| | Min-max | 65-105 | 65-105 | 67-103 | |
| Age (years) | 65-74 | 58 (%29) | 39 (%28.7) | 19 (%29.7) | 0.475 ($\chi^2$=1.487) |
| | 75-84 | 81 (%40.5) | 52 (%38.2) | 29 (%45.3) | |
| | <85 | 61 (%30.5) | 45 (%33.1) | 16 (%25) | |
| Sex | Male | 70 (%35) | 51 (%37.5) | 19 (%29.7) | 0.28 ($\chi^2$=1.168) |
| | Female | 130 (%65) | 85 (%62.5) | 45 (%70.3) | |
| Type of Anesthesia | Spinal block | 139 (%69.5) | 95 (%69.9) | 44 (%68.8) | 0.874 ($\chi^2$=0.025) |
| | General | 61 (30.5%) | 41 (30.1%) | 20 (31.3%) | |
| Fracture Type | Intertrochanteric | 137 (68.5%) | 95 (69.9%) | 42 (65.6%) | 0.548 ($\chi^2$=0.361) |
| | Femoral Neck | 63 (31.5%) | 41 (30.1%) | 22 (34.4%) | |
| Time to surgery (day) | Mean±S.D | 4.83±3.62 | 4.83±3.84 | 4.83±3.14 | 0.721 (z=-0.358) |
| | Med (IQR) | 4 (3-6) | 4 (3-6) | 4.5 (2-6.75) | |
| | Min-max | 1-35 | 1-35 | 1-17 | |
| Stay in Hospital (day) | Mean±S.D | 10.49±5.85 | 10.35±5.93 | 10.78±5.72 | 0.499 (z=-0.677) |
| | Med (IQR) | 9 (7-12) | 9 (7-12) | 9 (8-12) | |
| | Min-max | 3-51 | 3-51 | 4-35 | |
| ASA score | Mean±S.D | 2.76±0.86 | 2.54±0.87 | 3.23±0.64 | 0.0001* (z=-5.472) |
| | Med (IQR) | 3 (2-3) | 3 (2-3) | 3 (3-4) | |
| | Min-max | 1-4 | 1-4 | 1-4 | |
| CCI | Mean±S.D | 5.83±1.53 | 5.38±1.53 | 6.78±0.98 | 0.0001* (z=-6.156) |
| | Med (IQR) | 6 (5-7) | 6 (4-6.75) | 7 (6-7) | |
| | Min-max | 1-9 | 1-8 | 5-9 | |
| Treatment type | Internal Fixation | 116 (58%) | 80 (58.8%) | 36 (56.3%) | 0.731 ($\chi^2$=0.118) |
| | Arthroplasty | 84 (42%) | 56 (41.2%) | 28 (43.8%) | |
| Comorbidities | | | | | |
| Cardiovascular | No | 86 (43%) | 77 (56.6%) | 9 (14.1%) | 0.0001* ($\chi^2$=32.155) |
| | Yes | 114 (57%) | 59 (43.4%) | 55 (85. 9%) | |
| Renal | No | 167 (83.5%) | 118 (86.8%) | 49 (76.6%) | 0.07 ($\chi^2$=3.288) |
| | Yes | 33 (16.5%) | 18 (13.2%) | 15 (23.4%) | |
| Pulmonary | No | 163 (81.5%) | 111 (81.6%) | 52 (81.3%) | 0.95 ($\chi^2$=0.004) |
| | Yes | 37 (18.5%) | 25 (18.4%) | 12 (18.8%) | |
| Central nervous | No | 152 (76%) | 109 (80.1%) | 43 (67.2%) | 0.045* ($\chi^2$=4.007) |
| | Yes | 48 (24%) | 27 (19.9%) | 21 (32.8%) | |
| Endocrine | No | 131 (65.5%) | 91 (66.9%) | 40 (62.5%) | 0.54 ($\chi^2$=0.375) |
| | Yes | 69 (34.5%) | 45 (33.1%) | 24 (37.5%) | |

**p*<0.05 statistically significant; S.D: Standard Deviation; Med (IQR): Median (IQR): Median (25$^{th}$ - 75$^{th}$ percentiles); Min-max: Minimum-maximum values; $\chi^2$: Chi-square test; z: Mann Whitney U test. ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index.

In hip fracture patients, overall mortality, in-patient or 1-month mortality, was reported to be 13.3%, 3-6 months 15.8%, 1 year 24.5%, and 2 years 34.5%[4]. The risk of in-hospital mortality is estimated to be between 4% and 12%[12]. Our in-hospital mortality rate was as high as 32%. Our study also included the peak period of COVID-19. We believe that our mortality rate is high due to both preoperative and postoperative COVID-19. In addition, because a significant portion of intensive care beds were reserved for COVID-19 patients during these peak periods, there were delays in surgeries, and it was not always possible to arrange intensive care beds for patients. Our hospital is the

**Table III.** Risk factors associated with in-hospital death of geriatric hip fracture patients.

| | Univariate | | | Multiple | | |
|---|---|---|---|---|---|---|
| | *p* | O.R. | 95% C.I. Lower-Upper | *p* | O.R. | 95% C.I. Lower-Upper |
| Age | 0.818 | 1.004 | 0.971-1.038 | - | - | - |
| Age years 65-74 | 0.71 | 1.145 | 0.562-2.333 | - | - | - |
| Age years 75-84 | 0.435 | 0.73 | 0.331-1.61 | - | - | - |
| Sex | 0.281 | 1.421 | 0.75-2.692 | - | - | - |
| Time to surgery | 0.996 | 1 | 0.921-1.086 | - | - | - |
| To Stay in Hospital (day) | 0.624 | 1.012 | 0.964-1.064 | - | - | - |
| ASA Score | 0.0001* | 3.197 | 2.021-5.059 | 0.242 | 1.434 | 0.784-2.621 |
| Type of Anesthesia | 0.874 | 1.053 | 0.554-2.003 | - | - | - |
| Fracture Type | 0.548 | 1.214 | 0.645-2.285 | - | - | - |
| | 0.731 | 1.111 | 0.61-2.025 | - | - | - |
| Cardiovascular | 0.0001* | 7.976 | 3.648-17.435 | 0.0001* | 5.049 | 2.143-11.891 |
| Renal | 0.073 | 2.007 | 0.937-4.299 | - | - | - |
| Pulmonary | 0.95 | 1.025 | 0.478-2.198 | - | - | - |
| Central nervous | 0.047* | 1.972 | 1.008-3.855 | 0.795 | 0.899 | 0.402-2.007 |
| Endocrine | 0.541 | 1.213 | 0.653-2.254 | - | - | - |
| CCI | 0.0001* | 2.377 | 1.744-3.242 | 0.0001* | 2.03 | 1.393-2.958 |

*$p<0.05$ statistically significant; OR: Odds Ratio; 95% CI: 95% Confidence Interval. ASA, American Society of Anesthesiologists; CCI, Charlson Comorbiditiy Index.

largest in this region. For this reason, patients with complicated and intensive care needs are referred to us from other hospitals. We believe that our mortality rates are high for all these reasons.

There are many different studies in favor of and against early treatment of proximal femur fracture. In some studies[13,14], in-hospital mortality increased if the duration of surgery was longer than 48 h. Moran et al[15] reported that delaying hip fracture surgery for up to four days did not increase mortality; however, mortality increased significantly with a delay of more than four days. Beaupre et al[16] reported that mortality increased significantly with increasing operative time and age. In addition, those aged ≥85 years were more affected by delays in the operative time. Smektala et al[17], in a prospective observational study of 2,916 patients aged 65 years and older, reported a trend towards more frequent postoperative complications in the longest time to surgery group, but that time to surgery had no effect on mortality. In our patients, the median operating time was 4 days and was not associated with mortality. The operations were delayed for three main reasons; mostly due to insignificant electrocardiographic abnormalities, sometimes due to late admission to the institute, and sometimes for patients in poor health who needed a dedicated intensive care room for the postoperative period. We found that delay in surgery significantly increased the mortality rate. It has also been suggested that patients should be operated on as early as possible, as early treatment reduces pain and increases mobility, which in turn reduces pulmonary complications (atelectasis, pulmonary thromboembolism, and pneumonia).

The choice of anesthesia in hip fracture patients is still controversial. Some studies[18,19] advocate regional anesthesia, while others advocate general anesthesia. In some meta-analyses[18,19], no difference was found between general and spinal anesthesia in terms of HST mortality. In this study, no differences were found between the type of anesthesia and mortality.

Most of our patients were women (65%). In 68 studies evaluated in a meta-analysis[4], most of the patients were women, and the female rate was 61%-87.7%. These results are similar to those of our study. Female gender and advanced age are risk factors for femoral fractures[20].

The in-hospital mortality rate of hip fractures is between 1% and 2% in patients without comorbidities. As comorbidities increase, the rate also increases significantly[21]. In the HEMA study[22], evaluating in-hospital mortality, a history of myocardial infarction, and congestive heart failure were both predictive factors for mortality. Similar to our study, many previous studies[12,23-25] have determined that the risk of postoperative mortality increases in patients with preoperative heart disease.

In hip fracture patients, CCI and ASA scores have attracted the interest of researchers in determining mortality at different time periods after surgery. In this study, we aimed to evaluate their value in predicting in-hospital mortality. Some studies[21,26] emphasize ASA, while others emphasize CCI. Some studies have reported that CCI calculated by adding age and sex is more valuable for predicting in-hospital mortality. In our study, we calculated the CCI, including age and sex.

Smith et al[27], in a meta-analysis of fifty-three studies involving 544,733 participants, showed that high ASA grade and high Charlson comorbidity score at admission were associated with increased mortality. In a study[28] of 1,004 patients, both univariate and multivariate logistic regression analyses of in-hospital mortality identified ASA and CCI as important risk factors for inpatient mortality. Another study[29] showed that the CCI and ASA models have equal predictive abilities for mortality after hip fracture in patients aged 65 years and older. Therefore, the model was modified accordingly. Given the effort involved in calculating the CCI score, the ASA score may be the preferred tool for predicting mortality within 30 days after hip fracture. Although an increase in ASA grade does not affect mortality, studies[30] have found that CCI increases. Nkanang et al[31] found ASA 3 and above to be associated with high mortality in their study on perioperative mortality.

The CCI score provides more detailed scoring than the ASA classification. However, health status and lifestyle factors such as smoking, and obesity may be associated with mortality and are considered when recording the ASA score but not in the CCI. Obtaining data and calculating the CCI score is time-consuming, whereas the ASA score is easy to implement.

Although pre-existing comorbidities appear to be associated with an increased risk of mortality after hip fracture, their relative importance in the prognosis of in-hospital mortality has not been documented. Several in-hospital mortality prediction models have been proposed for patients with hip fractures; however, no reliable prediction models have been established. Karres et al[22] applied six prediction models to patients with hip fractures, and none of the models convincingly discriminated between predicting 30-day mortality. Similarly, Nelson et al[32] directly compared three well-known predictive models for mortality in elderly patients after hip fracture and concluded that these models did not differ significantly in the accuracy of mortality prediction.

In different studies[33-35] conducted on hip fracture failures, it has been determined that there is no relationship between the type of fracture, the surgical method applied, and mortality. Kesmezacar et al[36] reported no difference in mortality between intertrochanteric and femoral neck fractures and argued that internal fixation would decrease mortality. Vestergaard et al[25] reported higher mortality rates in patients who underwent arthroplasty. There was no difference in mortality between the 116 patients treated with internal fixation and the 84 patients treated with hemiarthroplasty.

### *Limitations*

First, the study was conducted retrospectively, and there was no chance of intervention in some variables. Second, we only evaluated in-hospital mortality. We did not evaluate the long-term mortality due to incomplete patient information. Third, we could not evaluate many factors, such as the hemoglobin levels of patients, the presence of malnutrition, and body mass index. Finally, postoperative processes, such as the development of postoperative delirium, morbidities, and causes of death, could not be evaluated. Additionally, our study included the peak periods of COVID-19. These processes especially affected our mortality results due to reasons such as patient preparation, difficulties in postoperative intensive care bed adjustment, and COVID-19 RT-PCR positivity of patients both preoperatively and postoperatively. We believe that there is a need for prediction models in which patient age, frailty, malnutrition status, hemoglobin levels, ASA, and CCI are evaluated together.

## Conclusions

Hip fractures in elderly patients with an increasing life expectancy continue to be an important problem. In this study, CCI and cardiac pathology were associated with mortality. The type of hip fracture, surgical method, and anesthesia method were not associated with mortality. Patients over 65 years of age with hip fractures and additional comorbidities should be followed up more closely and evaluated well in terms of the need for intensive care.

### Conflict of Interest
The Authors declare that they have no conflicts of interest.


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This study did not receive any financial support.


### Informed Consent
Informed consent was waived due to the retrospective nature of the study.

### Ethics Approval
The study was conducted by the guidelines of the Helsinki Declaration and verified by the Clinical Research Ethics Committee of Balıkesir University Faculty of Medicine on November 16, 2022 (decision No. 2022/128).


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### Authors' Contributions
All authors have made substantial contributions to the conception and design of the study, data acquisition, data analysis and interpretation, drafting of the article or critically revising it for important intellectual content, and final approval of the version to be submitted.

### Availability of Data and Materials
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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