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Short- and Long-Term Predictive Value of CCI in Patients with Hip Fracture

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ABSTRACT

The present study aimed to evaluate the relationship between Charlson Comorbidity Index (CCI) and 1-year mortality in surgically treated the older adult hip fracture population and to compare the predictive values among patients with different CCI scores.

We retrospectively analyzed 352 patients (114 men, 238 women) aged ≥60 years (range, 60–100 years) who underwent surgical treatment for hip fractures in our clinic between February 2017 and February 2020. Necessary information such as age, sex, and diagnosed comorbidities were obtained through archive records. In addition, the date of death—if deceased—was learned by telephonically contacting the patients' relatives. Patients were divided into deceased and surviving groups, i.e., those who died within 1 year after surgery and those who survived, respectively, and were comparatively analyzed in terms of factors affecting mortality.

The postoperative 1-year mortality rate of the 352 patients included in this study was 36.4%. The deceased group (83.5 ± 7.8 years) had a significantly higher mean age than the surviving group (80.2 ± 9.7 years; $p = 0.001$). Men had significantly higher 1-year mortality rates than women ($p = 0.044$). Chronic kidney failure, congestive heart failure, and dementia had significant predictive effects on mortality ($p = 0.002$, 0.022, 0.037, respectively). Compared with other categories, CCI category 3 had a statistically significant odds ratio of 2.021 (95% CI: 1.014– 4.025; $p = 0.045$).

The correlative abilities of CCI appeared to affect mortality categorically and were also effective over a period of 1 year.

Keywords: Hip fractures, Comorbidity, Charlson Comorbidity Index (CCI)

Introduction

Hip fractures have become an important health problem owing to their association with morbidity and mortality and the increasing elderly population. The 1- and 8-year mortality rate following hip fracture is as high as 30% and 80%; furthermore, 40% of patients could not return to their initial ambulatory state. Patients who were re-admitted to hospital within 30 days of discharge following a hip fracture had a relatively poorer prognosis, with twice the risk of death within the first year (1).

Although predictive markers for mortality after hip fracture have been extensively researched thus far, the research on risk estimation models and their use has remained relatively limited. These models can help in risk stratification for each patient and to understand the prognosis while evaluating the patient. In this way, outcomes can be improved by preoperative evaluation of risk factors and taking precautions on an individual basis. Brabant Hip Fracture Score, Nottingham Hip Fracture Score, Charlson Comorbidity Index (CCI) and Almelo Hip Fracture Score are the most commonly used scores for mortality estimation. However, aside from CCI, these scores include variables such as a scoring based on patient's nursing home stay status and mini mental state examination (MMSE)(2). One of these clinical prediction models, CCI can be used as an easy, inexpensive and fast evaluation method (3,4).

CCI has previously been used to predict mortality, but there is a paucity of studies have been performed in patients with hip fractures that address other comorbid factors such as Dementia's and hypothyroidism, among others (5,6). Although there is a significant relationship between hypothyroidism and mortality, the effect is likely indirect and results from multiple events such as malnutrition and presence of acute and chronic diseases (7).

We chose to use the CCI because it takes into account major medical comorbidities and is highly predictive of postoperative complications in hip fracture patients. Significant predictive values of

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CCI can be used to reduce possible postoperative complications and consequently reduce mortality after hip fracture.

In the present study, we examined the predictive effect of CCI in patients operated after hip fracture, as well as the relationship between mortality and thyroid disorder, Dementia's disease, and other comorbid factors.

The present study aimed to evaluate the relationship between CCI and 1-year mortality in the surgically treated older adult hip fracture population and to compare the predictive values among patients with different CCI scores. The authors hypothesized that patients with increasing age, male sex, and higher CCI scores have a higher risk of 1-year mortality.

Materials and Methods

Patients: Patients who applied to the Orthopedics and Traumatology Clinic of our hospital between February 2017 and February 2020 for hip fracture after a simple fall and underwent surgical treatment were evaluated retrospectively. The study included 352 patients aged ≥60 years (114 men and 238 women; age range, 60–100 years), whose follow-up period was at least 1 year and who had relatives who could be contacted.

Prior to the study, approval was obtained from the Clinical Research Ethics Committee of the Hospital. The study was based on the hip fracture database of the Hospital. Patients aged >60 years who visited our clinic with the complaint of hip fracture and subsequently underwent surgical treatment were included in the study.

Patients presenting with malignancy and fractures after high-energy trauma were excluded from the study.

In the present study, we have used the hip fracture database of the Hospital. A data file was created for each patient by examining the patient file. The data file included information such as sex, age, date of surgery, existing comorbidities (comorbid factors), and, if the patient died, date of death.

The primary endpoint was determined as 1-year all-cause death. Date of death - if deceased - was learned by telephone conversations with the patient's relatives. Data were handled as date of birth, sex, and vital status. CCI was used as the scoring system. A scoring system was defined according to the determined comorbidity of the patients. The scoring system was designed and approved, including a total of 17 comorbid factors according to the given scores (8).

Patients were evaluated according to CCI score, sex, age groups, and comorbid diagnoses. Considering the time of death of the patients after surgery, 30-day and 1-year mortality were analyzed and presented in Tables.

Comorbid factors which have an effect on mortality according to the literature such as diabetes mellitus, dementia, hypertension, chronic lung disease [asthma, Chronic obstructive pulmonary disease(COPD)], congestive heart failure, chronic kidney failure, arrhythmia, malignancy, vascular diseases, and embolism were investigated(9).

Statistical Analysis: Variables were summarized using mean ± standard deviations and frequency (percentages) where appropriate. Univariate logistic regression analysis was used to assess the relationship between the survival and the predictors of interest. For the multivariate analysis, multiple logistic regression was used and the odds ratios (OR) for each factor was assessed after controlling for other variables. The variables which were found to be statistically significant in the univariate analysis, were included in the multivariate analysis. Goodness of fit of the logistic regression models were confirmed with Hosmer-Lemeshow tests. The general pattern of 1-year survival with respect to CCI of the patients were evaluated with Kaplan Meier plot. The log-rank test was used to test for difference in 1-year survival. The analyses were performed using the Statistical Package for Social Sciences 25.0 for Windows (SPSS Inc., Chicago, Illinois, USA). The results were considered to be significant at a level of $p < 0.05$.

Results

The predictors of 30-days and 1-year mortality were assessed by univariate analysis in Table 1 and Table 2, respectively. Multivariate analysis was performed to evaluate the relationship between survival and predictors that were found to be statistically significant in the univariate analysis. In the multivariate analysis, age (OR:1.060, 1.002-1.122, p=0.043), Chronic renal failure (OR:4.602, 1.464-14.468 p=0.009), Congestive heart failure (OR: 3.159, 1.210-8.244, p=0.019) and Diabetes (OR: 3.763, 1.490-9.502, p=0.005) were identified as the statistically significant predictors of 30-days mortality (Table 3).

For 1-year mortality, age (OR:1.041, 1.008-1.074, p=0.013), Chronic renal failure (OR: 3.905, 1.668 - 9.142, p=0.002), Congestive heart failure (OR: 2.175, 1.121 - 4.221, p=0.022), Dementia (OR:

Table 1. Univariate analysis of preoperative predictors of 30-days Mortality

Characteristics	Dead (n=28)	Alive (n=324)	OR (95%CI)	p
Age (mean years ± SD)	83.9±7.2	81.1±9.3	1.037 (0.989-1.086)	0.134
Gender (Male, n %)	14 (50.0)	100 (30.9)	2.240 (1.030-4.874	0.042
CCI (n %) a				
0-1	8 (28.6)	130 (40.1)	reference	
2	12 (42.9)	118 (36.4)	1.653 (0.653-4.183)	0.289
3	6 (21.4)	62 (19.1)	1.573 (0.523-4.728)	0.420
≥4	2 (7.1)	14 (4.3)	2.321 (0.448-12.023)	0.316
Chronic renal failure (n %)	8 (28.6)	28 (8.6)	4.229 (1.707-10.472)	0.002
Hypertension (n %)	20 (71.4)	178 (54.9)	2.051 (0.878-4.791)	0.097
Congestive heart failure (n %)	12 (42.9)	52 (16.0)	3.923 (1.754-8.776)	0.001
Dementia (n %)	10 (35.7)	94 (29.0)	1.359 (0.605-3.054)	0.457
Diabetes (n %)	10 (35.7)	56 (17.3)	2.659 (1.165-6.066)	0.020
Cerebrovascular disease (n %)	0 (0)	16 (4.9)	NA	NA
Arrhythmia (n %)	6 (21.4)	32 (9.9)	2.489 (0.940-6.589)	0.066
COPD (n %)	4 (14.3)	50 (15.4)	0.913 (0.304-2.745)	0.872
Hypothyroidism (n %)	4 (14.3)	32 (9.9)	1.521 (0.496-4.660)	0.463
Thyrotoxicosis (n %)	0 (0)	6 (1.9)	NA	NA
Embolism (n %)	0 (0)	14 (4.3)	NA	NA
Malignancy (n %)	0 (0)	20 (6.2)	NA	NA

[a]Categories with zero observations were combined with the nearest category. OR:Odds Ratio. CI:Confidence Interval. COPD: Chronic obstructive pulmonary disease. NA: Not Applicable

1.776, 1.035 - 3.048, p=0.037) and CCI category identified in Table 4 were found to be independent predictors. The OR of 1-year mortality was almost 2 times higher in patients with an CCI category of 3, when compared to patients with CCI of 1 or lower (OR: 2.021, 1.014-4.025, p=0.045).

The overall 30-day mortality was 8% (n=28) and 1- year mortality was 36.4% (n=128). Kaplan-Meier curves for 1-year mortality are shown in (Figure) 1. Mortality was significantly different between the four groups of CCI (log-rank test p<0.001).

Discussion

There are many clinical estimation methods of comorbidity in the literature. (2) MMSE is one of the difficult variables to obtain in the case of hip fracture. In addition, since most older adult people do not stay in nursing homes in the Black Sea Region culture, CCI was selected as the scoring system in the present study. In this study, it was aimed to determine the mortality rate in the older adult patient population operated for hip fracture and to show the predictive value of CCI for 30-day and 1-year mortality after surgical treatment of hip fracture. In the present study, previously diagnosed comorbidities, which we think affect the mortality of the patients, were also considered as potential variables. We can say that patients with a CCI score of 3 have a 2-fold increased risk of 1-year mortality compared to patients with lower scores.

Ling et al. reported a relationship between preoperatively impaired TFT and postoperative complications in hip fracture patients, but could not find a correlation (10). Buller et al. examined the effect of hypothyroidism on the postoperative period in patients who underwent surgery for total knee replacement and found a significant increase in complications in the postoperative period (11). Consistent with the literature, we did not find a statistically significant difference.

Hasan et al.(12) found that patients with a high CCI score after hip fracture surgery had a 1.45 times higher risk of developing postoperative complications compared to patients with a low CCI score. But in our study, the OR of 1-year mortality was almost 2 times higher in patients with an CCI category of 3.

Soto et al. observed that in patients aged ≥65 years, the 1-year mortality rate after hip fracture has been reported as 30% (13). Although there are studies reporting a 1-year mortality rate of 36%, one year after surgery, 58% of survivors have

Table 2. Univariate Analysis of Preoperative Predictors of 1-Year Mortality

Characteristics	Dead (n=128)	Alive (n=224)	OR (95%CI)	P
Age (mean years ± SD)	83.5±7.8	80.2±9.7	1.044 (1.017-1.074)	0.001
Gender (Male, n %)	50 (39.1)	64 (28.6)	1.603 (1.013-2.534)	0.044
CCI (n %) a				
0-1	40 (31.3)	98 (43.6)	reference	
2	40 (31.3)	90 (40.2)	1.089 (0.645-1.838)	0.750
3	42 (32.8)	26 (11.6)	3.958 (2.146-7.298)	<0.001
≥4	6 (4.7)	10 (4.5)	1.470 (0.501-4.315)	0.483
Chronic renal failure (n %)	26 (20.3)	10 (4.5)	5.455 (2.535-11.740)	<0.001
Hypertension (n %)	76 (59.4)	122 (54.5)	1.222 (0.787-1.897)	0.372
Congestive heart failure (n %)	36 (28.1)	28 (12.5)	2.739 (1.576-4.759)	<0.001
Dementia (n %)	52 (40.6)	52 (23.2)	2.263 (1.415-3.620)	0.001
Diabetes (n %)	24 (18.8)	42 (18.8)	1.000 (0.573-1.744)	1.000
Cerebrovascular disease (n %)	4 (3.1)	12 (5.4)	0.339 (0.180-1.805)	0.339
Arrhythmia (n %)	18 (14.1)	20 (8.9)	1.669 (0.848-3.287)	0.138
COPD (n %)	26 (20.3)	28 (12.5)	1.784 (0.994-3.203)	0.052
Hypothyroidism (n %)	10 (7.8)	26 (11.6)	0.645 (0.301-1.386)	0.261
Thyrotoxicosis (n %)	2 (1.6)	4 (1.8)	0.873 (0.158-4.834)	0.876
Embolism (n %)	2 (1.6)	12 (5.4)	0.280 (0.062-1.273)	0.100
Malignancy (n %)	8 (6.3)	12 (5.4)	1.178 (0.468-2.962)	0.728

[a]Categories with zero observations were combined with the nearest category. CCI:Charlson Comorbidity Index OR: Odds Ratio. CI: Confidence Interval. COPD: Chronic obstructive pulmonary disease. NA: Not Applicable

Table 3. Multivariate Analysis of Predictors of 30-days Mortality

	OR	95% CI	p
Age (mean years+SD)	1.060	1.002 - 1.122	0.043
Gender (Male, n %)	0.427	0.169 - 1.076	0.071
CCI (n %)			
0-1	reference		
2	0.882	0.307 - 2.534	0.815
3	0.327	0.076 - 1.409	0.134
≥4	1.092	0.136 - 8.741	0.934
Chronic renal failure (n %)	4.602	1.464 - 14.468	0.009
Congestive heart failure (n %)	3.159	1.210 - 8.244	0.019
Diabetes (n %)	3.763	1.490 - 9.502	0.005

CCI: Charlson Comorbidity Index OR:Odds Ratio. CI:Confidence Interval

difficulty performing daily tasks in ambulation without an assistive device(14). According to our results, the 1-year mortality rate was calculated as 36.4%.

Xing et al.(15) formulated "risk-adjusted CCI scores of patients" as "0.099 × age (years) + 0.355 × time from injury to surgery (days) + 0.444 × CCI scores" in patients with hip fractures. In the present study, multivariate analysis showed that odds ratio was 1.041 for age, 0.726 for male sex, and 2.021 for CCI 3 category.

In the Norwegian epidemiological study of Riska et al. in hip fractures aged >50 years, all comorbid diagnoses except rheumatic disease were relatively more common in men. Dementia was the most common diagnosis in women (12%), whereas chronic lung disease and dementia were equally common in men (14%). For those diagnosed with dementia, the adjusted 1-year mortality rate was 36% in women and 57% in men. Mortality rates were higher in men for all registered CCI diagnoses(16). In our study, male gender was a predictor factor for 30 day and 1 year mortality.

Table 4. Multivariate Analysis of Predictors of 1-year Mortality

	OR	95% CI	p
Age (mean years+SD)	1.041	1.008 - 1.074	0.013
Gender (Male, n %)	0.726	0.420 - 1.253	0.250
CCI (n %)			
0-1	reference		
2	0.766	0.430 - 1.363	0.365
3	2.021	1.014 - 4.025	0.045
≥4	1.255	0.351 - 4.481	0.726
Chronic renal failure (n %)	3.905	1.668 - 9.142	0.002
Congestive heart failure (n %)	2.175	1.121 - 4.221	0.022
Dementia (n %)	1.776	1.035 - 3.048	0.037

CCI: Charlson Comorbidity Index OR: Odds Ratio. CI: Confidence Interval

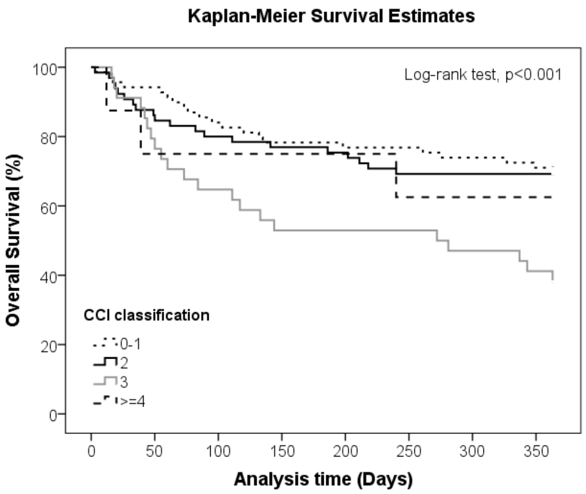

Fig. 1. Kaplan-Meier survival curves of 1-year survival of patients in the different CCI categories

Jennison et al. examined 30-day mortality in patients with periprosthetic hip fractures, and found that 53.1% were CCI 0–1, 31.3% were CCI 2–3, and 15.6% were CCI ≥5. In terms of 30-day mortality, mean age was 78.5 years for surviving patients and 81.3 years for deceased patients. In terms of 1-year mortality, mean age was 77.2 years for surviving patients and 83.1 years for deceased patients (17).

Lei et al. observed that(18) patients with an ACCI category of ≤3, 4–5, and ≥6 had a 1-year mortality rate of 1.3%, 10.6%, and 22%, respectively. 1-year mortality was statistically significant in those with CCI category 3, and its odd ratio was 2.0.

Tang et al. found that the CCI score showed in predicting in-hospital mortality (OR: 1.341, 95% confidence interval (CI): 1.236-1.455, p < 0.0001). Moreover, age grouping (OR:1.973, 95% CI: 1.385-2.811, p: 0.0002) and sex (OR: 1.654, 95% CI: 1.200-2.280, p: 0.0021) were significant factors related to in-hospital mortality in the CCI models(4). In the present study, mean age (mean ± SD) was 83.5 ± 7.8 years and the odds ratio was 1.044, which was consistent with the literature.

Jiang et al. calculated the dementia rate as 74% and the odds ratio as 2.22 in his study in Asian patients with hip fractures (18). In the present study of hip fracture patients, the rate of dementia was 40.6% in surviving patients and 23.2% in deceased patients. The odds ratio was 1.776.

There are certain limitations of this study. This study did not include patients with hip fractures who received non-surgical treatment, and if these patients were included, different calculations could have been made in determining the differences in 1-year mortality rates. Finally, other potential confounding factors such as initial injury severity scores, pre-illness quality of life indices, and nursing home residents were excluded from the study as they could not be controlled.

Our hypothesis that increasing age, male gender and higher CCI score are associated with a higher postoperative complication rate validated according to the statistical results we obtained. In addition, the correlative abilities of CCI appeared to affect mortality categorically and were also effective over a period of 1 year. This information is vital, especially in an aging population, and a reduction in mortality can be achieved through close follow-up of high-risk patients by providing greater access to health services with accurate identification. This is particularly relevant to studies showing that postoperative hip fracture mortality is actually increased in some populations and even geographies.

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