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Prediction of 5-Year Survival Rate After Hip Fracture Surgery Using a Comprehensive Geriatric Assessment-Based Frailty Score Model

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ABSTRACT

Background: Hip fractures (HFs) are major osteoporotic injuries associated with morbidity, loss of independence, increased mortality, and an increased socioeconomic burden. The total number of HFs is increasing owing to an aging population. While studies have focused on 30-day or 1-year mortality after HF surgery, studies reporting long-term mortality are lacking. Our study bridges this knowledge gap by exploring the relationship between frailty, postoperative complications, and the 5-year mortality after HF surgery. This study aimed to identify the risk factors associated with 5-year mortality after HF surgery. The impact of the Hip-Multidimensional Frailty Score (Hip-MFS) and postoperative complications on 5-year mortality was compared.
Methods: This retrospective study included 536 individuals aged 65 years and older with HFs who underwent surgery between 2009 and 2014. The Hip-MFS was calculated using the comprehensive geriatric assessment. Patients whose Hip-MFS score above 8 considered as frail. Postoperative complications included pneumonia, urinary tract infection, delirium, pulmonary thromboembolism, and unplanned intensive care unit admission after surgery. The primary outcome was 5-year mortality. Univariate and multivariate cox-regression, Kaplan–Meier analysis and log-rank tests were used to assess predictive value of frailty and postoperative complications on 5-year mortality.
Results: The mean age was 80.5 ± 7.0 years and 71.3% (n = 382) were women. Overall, 48.3% (n = 259) were diagnosed with femoral neck fractures, and 51.7% (n = 277) were diagnosed with intertrochanteric fractures. A total of 223 (41.6%) patients experienced postoperative complications. The overall mortality rate was 60.4% (n = 324), with 1-year and 5-year mortality rates after HF surgery being 13.8% (n = 74) and 43.8% (n = 235), respectively. In the multivariate regression analysis, after adjusting for clinical and demographic factors, the high-risk Hip-MFS group and the group with postoperative complications had hazard ratios for 5-year survival of 1.513 (95% confidence interval [CI], 1.105–2.017; $P = 0.010$) and 1.470 (95% CI, 1.117–1.936; $P = 0.006$), respectively. Patients who had postoperative complications with a low Hip-MFS showed better 5-year survival than those without postoperative complications with a high Hip-MFS in the Kaplan–Meier curve ($P = 0.013$).
Conclusion: A high Hip-MFS risk and postoperative complications were associated with an increased 5-year mortality rate. In comparison to the occurrence of postoperative

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Data Availability Statement
Anonymized datasets can be made available on reasonable requests after approval from the trial management committee and after signing a data access agreement. Proposals should be directed at the corresponding author.

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complications, the frailty status evaluated using the Hip-MFS had a more significant impact on long-term mortality after HF surgery.

Keywords: Frailty; Postoperative Complications; Mortality; Hip Fracture Surgery; Older Patients

INTRODUCTION

Hip fracture (HF) is a major osteoporotic injury associated with morbidity, loss of independence, increased mortality, and an increased socioeconomic burden. While the age-adjusted HF incidence rate remains steady or declines because of improved osteoporosis and multimorbidity management, the total number of HFs is increasing owing to an aging population.[1] The incidence of HF is estimated to increase 1.4 times over the next 10 years, and the 1-year cumulative mortality rate in Korea was 16.0% in 2012.[1] The mortality rate sharply decreases from 1 year after HF, and the annual mortality rate decreases over time.[1,2] Complications after HF surgery are common, and their occurrence is associated with an elevated mortality rate. Therefore, efforts are being made to reduce complications and improve mortality rates.[3] As most morbidity or mortality is due to general medical conditions and not the fracture itself, candidates for perioperative geriatric interventions should be identified to reduce risk.[4,5]

Frailty is defined as a vulnerable state accompanied by various preliminary physiological reserves that result in a poor resolution of homeostasis when exposed to stressors such as surgery.[6] Frailty has been reported to be a poor prognostic indicator of adverse events, including mortality, complications, length of hospital stay, functional status, quality of life, and discharge disposition.[7] The Hip-Multidimensional Frailty Score (Hip-MFS), calculated from the comprehensive geriatric assessment (CGA) using the concept of cumulative deficit to assess frailty, was developed and validated to predict adverse outcomes and short-term mortality more precisely than chronological age, conventional risk stratification tools, or grip strength after HF surgery.[8-10]

Previous studies have reported an increased risk of mortality after HF surgery.[11] Osteoporotic HFs have comparable survival rates to thyroid and breast cancers, and there is a correlation between HFs and reduced life expectancy compared with the mortality rate in the general population.[12,13] While studies have focused on 30-day or 1-year mortality after HF surgery, limited studies reporting long-term mortality exist.[7,14,15] The risk of death after HF surgery is high when complications occur.[16] To our knowledge, only a few studies have explored the relationship between frailty or postoperative complications and the 5-year mortality after HF surgery.[17] Thus, we aimed to identify the prognostic utility of the composite frailty score (Hip-MFS) and postoperative complications on the 5-year mortality in older patients with HFs who underwent surgery.[18] Furthermore, we confirmed how frailty and postoperative complications influence each other based on 5-year mortality.

METHODS

Study population

Older patients with HFs (aged ≥ 65) admitted to a single 1,300-bed teaching tertiary hospital were evaluated between January 1, 2009, and December 31, 2014. Patients referred to a geriatric team for the pre-surgical CGA within 90 days were included in the study. If HF surgery was performed more than twice during the study period, only data from the first operation were included. Patients with missing Hip-MFS data were excluded. Additionally, among the participants admitted to the intensive care unit (ICU), high-risk patients who had no special medical or surgical problems but were admitted only for close monitoring were excluded. Baseline demographic, anthropometric, laboratory, and the American Society of Anesthesiologists (ASA) classification data were retrieved from electronic medical records.

Hip-MFS

The Hip-MFS was calculated from the CGA and laboratory test data as previously described and validated.[8,9] The CGA was used to evaluate comorbidity, problems associated with medication, physical and psychosocial function, nutritional status, risk of falling, and risk of postoperative delirium. Comorbidity was evaluated using the Charlson Comorbidity Index (CCI), which predicts the 10-year mortality for patients with various comorbid conditions.[19] Physical function was assessed on the basis of patients' activities of daily living (ADLs), instrumental ADLs (IADLs), and walking ability using the modified Barthel Index, Lawton & Brody Index, and Koval grade, respectively. Psychosocial function was determined by evaluating the patients' cognitive function and mood status using the Korean version of the Mini-Mental State Examination (MMSE-KC) and the Korean Geriatric Depression Scale. Nutritional status was assessed using the Mini Nutritional Assessment (MNA), and the risk of postoperative delirium was analyzed using the Nursing Delirium Screening Scale. The risk of falling was also evaluated on the basis of the Predisposition for Falling Assessment Guide because most cases of low-energy traumatic HF are caused by falls.

To calculate the Hip-MFS, eight clinical and demographic factors are used. For sex, assign 0 points if the patient is female and 1 point if male. For the CCI, assign 0 points for a score of 0, 1 point for a score between 1 and 2, and 2 points for a score greater than 2. For albumin levels, assign 0 points if the level is greater than 3.9 g/dL, 1 point if it is between 3.5 and 3.9 g/dL, and 2 points if it is below 3.5 g/dL. For the Koval grade, assign 0 points if the grade is 1, 1 point for a grade between 2 and 6, and 2 points for a grade of 7. For cognitive function as measured by the MMSE-KC, assign 0 points if the patient has normal cognitive function, 1 point for mild cognitive impairment, and 2 points for dementia. Regarding fall risk, if the patient is at risk of falling, assign 0 points; if not, assign 1 point. For the MNA, assign 0 points if the patient has a normal nutritional status, 1 point if they are at risk of malnutrition, and 2 points if they are malnourished. Lastly, for mid-arm circumference, assign 0 points if the circumference is greater than 27 cm, 1 point if it is between 24.6 and 27.0 cm, and 2 points if it is less than 24.6 cm. After assigning scores for each factor, sum all the points to obtain the patient's total Hip-MFS score. A practical assessment and calculation score has been described previously, and the cutoff value for identifying high-risk individuals (frail) was defined as a Hip-MFS > 8.[8]

Outcomes

The primary outcome was the 5-year all-cause mortality after HF surgery, assessed by the National Statistics Office from January 1, 2009, to December 31, 2019. The survival time was defined as the time from the surgery date to death. We identified predictive efficacy of Hip-MFS on 5-year all-cause mortality compared to chronological age and conventional anesthesiologic assessment (ASA classification).

Postoperative complications were retrospectively evaluated from the operation date to the discharge date. The postoperative complications included pneumonia, urinary tract infection, delirium, pulmonary thromboembolism, and unplanned ICU admission after surgery. Delirium was assessed by psychiatric consultation or retrospective chart review by one geriatrician (JY Choi) on the basis of the Diagnostic and Statistical Manual of Mental Disorders, 5th edition criteria.[20] Pneumonia, urinary tract infection, and pulmonary thromboembolism were assessed and diagnosed according to the standard National Surgical Quality Improvement Program definitions.[21] Unplanned ICU admission was defined as a transfer to an ICU within the hospitalization period after surgery for close monitoring of hemodynamic status, respiratory or renal failure, infection, or bleeding.

A total of 223 (41.6%) patients experienced postoperative complications including pneumonia (4.5%, n = 24), urinary tract infection (4.5%, n = 24), delirium (36.2%, n = 192), stroke (0.7%, n = 4), deep vein thrombosis (1.7%, n = 9), pulmonary thromboembolism (1.5%, n = 8), and unplanned ICU admission (5.0%, n = 27). Some patients had multiple postoperative complications (two [n = 13], three [n = 12], four [n = 2], and five complications [n = 1]). The median observation time was 1,999.5 days (interquartile range: 860.25–2,794.0). The overall mortality rate was 60.4% (n = 324), whereas the 1-year mortality and the 5-year mortality rate after HF surgery were 13.8% (n = 74) and 43.8% (n = 235), respectively. In this study, the presence of postoperative complications was analyzed as one of the risk factors affecting 5-year survival after surgery. We examined how the combination of frailty and postoperative complications influenced the 5-year survival rate.

Statistical analysis

Continuous variables are expressed as mean with standard deviation or median (interquartile range) and compared using the *t*-test. Categorical variables are presented as numbers or proportions, and the χ^2 or Fisher's exact test was performed. We explored the effects of potential risk factors, Hip-MFS, and postoperative complications on 5-year mortality using Cox proportional hazards analysis with univariate and multivariate analyses. Factors in the multivariate analysis included age, sex, body mass index (BMI), ASA classification, blood urea nitrogen (BUN), creatinine, hemoglobin, platelet count, total cholesterol, albumin levels, type of fracture, type of anesthesia, polypharmacy, Hip-MFS, and postoperative complications. These factors were selected to reduce clinical overfitting and were based on the results of the univariate analysis ($P < 0.3$). We identify the proportional hazards assumption through a visual assessment of log-log plots for the variables used in the Cox proportional hazards analysis. To determine whether postoperative complications and frailty independently predict 5-year mortality, both factors were included in the multivariate analysis. We compared the predictive value of the Hip-MFS for the primary outcome with ASA classification and chronological age using receiver operating characteristic (ROC) curves. We also included age and ASA classification as confounding variables in the multivariate Cox proportional hazards analysis to demonstrate that Hip-MFS still maintains statistical significance even after adjusting for age and ASA classification. Kaplan–Meier analysis was used to evaluate the survival curves, and log-rank tests were used to assess the significance between the risk groups. Risk groups were divided to: 1) patients who are robust and not experienced postoperative complication, 2) patients who are robust and experienced postoperative complication, 3) patients who are frail and not experienced postoperative complication, and 4) patients who are frail and experienced postoperative complication. All statistical analyses were performed using SPSS (version 25.0; IBM Corp., Armonk, NY, USA) and MedCalc Statistical Software version 17.5.3 (MedCalc Software, Ostend, Belgium).

Ethics statement

The study protocol was reviewed and approved by the Institutional Review Board of Seoul National University Hospital (B-2008-631-104), which waived the requirement for informed consent owing to the nature of the study. The study has been performed in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments.

RESULTS

During the study period, 1,363 patients underwent HF surgery. Of these, 589 (43.2%) patients underwent CGA. After excluding 53 patients with missing Hip-MFS data, 536 patients were included in the final analysis.

The mean age was 80.5 ± 7.0 years, and 71.3% (n = 382) were women. Among the patients, 48.3% (n = 259) were diagnosed with femoral neck fractures, and 51.7% (n = 277) were diagnosed with intertrochanteric fractures. Regarding surgical procedures, 67.5% (n = 362) underwent bipolar hemiarthroplasty, 22.6% (n = 121), 4.9% (n = 26), 3.9% (n = 21), and 1.1% (n = 6) underwent intramedullary nailing, multiple pinning, sliding hip screw, and total hip arthroplasty, respectively. Most patients received spinal or epidural anesthesia (87.7%, n = 470), whereas 12.3% (n = 66) received general anesthesia.

Older patients, male sex, a lower BMI, higher ASA classification, lower serum hemoglobin, cholesterol, protein, and albumin levels, and higher BUN and creatinine levels tended to associated with 5-year all-cause mortality. Among the CGA domains, dependent ADL, IADL, lower MMSE-KC, and MNA scores, mid-arm circumference, calf circumference, and positive risk of falling were associated with 5-year all-cause mortality. Higher CCI, Koval, and Hip-MFS scores were also correlated with 5-year all-cause mortality (**Table 1**).

The 5-year mortality rate of patients with postoperative complications was 58.3%, whereas that of patients without complications during hospitalization was 33.5% (hazard ratio [HR], 2.160; 95% confidence interval [CI], 1.669–2.795; $P < 0.001$). The 5-year mortality rates were 25.4% and 73.5% in the low- and high-risk Hip-MFS patient groups, respectively (HR, 3.154; 95% CI, 2.428–4.098; $P < 0.001$). The 5-year mortality rate exhibited a dose-response relationship, with an HR of 1.388 (95% CI, 1.300–1.482; $P < 0.001$) for every 1-point increase in the Hip-MFS (**Fig. 1**).

According to the univariate Cox regression analysis, older age, male sex, lower BMI, higher ASA classification, ADL and IADL dependence, lower MMSE score, risk of falling, higher BUN and creatinine levels, lower hemoglobin, total cholesterol, protein, and albumin levels, higher Hip-MFS, and postoperative complications were all associated with an increased risk of 5-year mortality after HF surgery. After adjusting for clinical and demographic factors in the multivariate regression analysis, the high-risk Hip-MFS and postoperative complication groups had HRs of 1.513 (95% CI, 1.105–2.071; $P = 0.010$) and 1.470 (95% CI, 1.117–1.936; $P = 0.006$), respectively (**Table 2**). The Hip-MFS was more accurate than the ASA classification in predicting 5-year all-cause mortality according to the area under the curve (AUC) of the ROC ($P < 0.001$) for analyzing the difference between the AUC of Hip-MFS (AUC, 0.746; 95% CI, 0.707–0.782) and the ASA classification (AUC, 0.586; 95% CI, 0.543–0.629). The Hip-MFS was also significantly superior to chronological age (AUC, 0.651; 95% CI, 0.609–0.692; $P < 0.001$) (**Fig. 2**).

Table 1. Comparison of demographic, laboratory, operation, and comprehensive geriatric assessment components by 5-year mortality

Characteristics	Survival (n = 301)	Death (n = 235)	*P* values
Demographic			
Age, yr	79.3 ± 6.7	82.0 ± 6.7	0.001
Sex (male)	76 (25.2)	78 (33.2)	0.044
Body mass index[a], kg/m^2	22.3 ± 3.7	20.4 ± 3.4	< 0.001
ASA class[a]			< 0.001
Class 1	24	4	
Class 2	195	134	
Class 3	79	95	
Class 4	3	2	
Operation related			
Operation time, min	71.7 ± 28.6	68.3 ± 31.5	0.192
Type of fracture			0.096
Femur neck fracture	155	104	
Intertrochanteric fracture	146	131	
Anesthesia			0.061
General	30	36	
Spinal	271	199	
Operation type			0.427
Total hip arthroplasty	5	1	
Bipolar hemiarthroplasty	209	153	
Sliding hip screw	9	12	
IM nail	59	62	
Multiple pinning	19	7	
Blood loss, mL	434.2 ± 367.5	399.4 ± 352.2	0.266
Laboratory			
WBCs, × 10^3/μL	9.4 ± 3.8	9.5 ± 4.2	0.716
Hemoglobin, g/dL	11.7 ± 1.7	10.9 ± 1.9	< 0.001
Platelets, × 10^3/μL	202.4 ± 70.0	208.3 ± 91.9	0.420
BUN, mg/dL	18.3 ± 7.4	23.4 ± 12.6	< 0.001
Creatinine, mg/dL	0.83 ± 0.52	1.25 ± 1.36	< 0.001
Total cholesterol, mg/dL	167.4 ± 39.2	158.4 ± 40.4	0.010
Protein, mg/dL	6.5 ± 0.7	6.3 ± 0.7	0.007
Albumin, mg/dL	3.8 ± 0.5	3.5 ± 0.5	< 0.001
Comprehensive geriatric assessment			
Charlson's comorbidity index	1.5 ± 1.6	2.1 ± 1.7	< 0.001
Polypharmacy (≥ 9)	104 (44.3)	120 (39.9)	0.307
ADL dependency (partial and full)	233 (77.4)	211 (89.8)	< 0.001
IADL dependency	207 (68.8)	205 (87.2)	< 0.001
MMSE-KC	18.4 ± 8.2	12.7 ± 8.7	< 0.001
SGDS-K[b]	4.8 ± 3.2	5.3 ± 4.0	0.188
Risk of falling (≥ 10)	199 (66.1)	198 (84.3)	< 0.001
MNA	21.7 ± 4.6	18.3 ± 5.3	< 0.001
Mid-arm circumference, cm	24.1 ± 3.0	22.3 ± 3.2	< 0.001
Calf circumference[c], cm	29.2 ± 4.0	27.4 ± 3.5	< 0.001
Koval grade	2.1 ± 1.6	2.9 ± 2.0	< 0.001
Hip-MFS	5.9 ± 2.2	7.9 ± 1.8	< 0.001

Data are presented as mean ± standard deviation or number (%).
ASA = American Society of Anesthesiologists, IM = intramedullary, WBC = white blood cell, BUN = blood urea nitrogen, ADL = activities of daily living, IADL = instrumental activities of daily living, MMSE-KC = Korean version of the Mini-Mental Status Examination, SGDS-K = Short Form of the Korean Geriatric Depression Scale, MNA = Mini Nutritional Assessment, Hip-MFS = Hip-Multidimensional Frailty Score.
[a]Data were missing for 1 patient.
[b]Data were missing for 157 patients.
[c]Data were missing for 38 patients.

To identify the interaction of postoperative complications and the Hip-MFS, Kaplan–Meier curves were compared. Patients with postoperative complications and a high-risk Hip-MFS (n = 83, 15.5%, red line) had the worst prognosis. In contrast, patients without postoperative

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Table 2. Factors associated with 5-year mortality among older patients with hip fractures according to multivariable Cox regression

Characteristics	HR	95% CI	*P* value
Age	1.043	1.021–1.065	< 0.001
Sex	0.733	0.544–0.987	0.041
BMI	0.934	0.897–1.972	0.001
ASA	1.096	0.866–1.387	0.447
Type of fracture	1.112	0.849–1.455	0.441
Anesthesia	0.890	0.618–1.281	0.529
Polypharmacy	1.051	0.798–1.386	0.722
BUN	1.011	0.998–1.024	0.098
Creatinine	1.137	1.014–1.276	0.028
Hemoglobin	1.013	0.984–1.043	0.376
Platelet	1.001	0.999–1.003	0.295
Total cholesterol	1.000	0.996–1.004	0.862
Albumin	0.687	0.488–0.966	0.031
High risk Hip-MFS (≥ 9)	1.513	1.105–2.071	0.010
Postoperative complication	1.470	1.117–1.936	0.006

HR = hazard ratio, CI = confidence interval, BMI = body mass index, ASA = American Society of Anesthesiologists, BUN = blood urea nitrogen, Hip-MFS = Hip-Multidimensional Frailty Score.

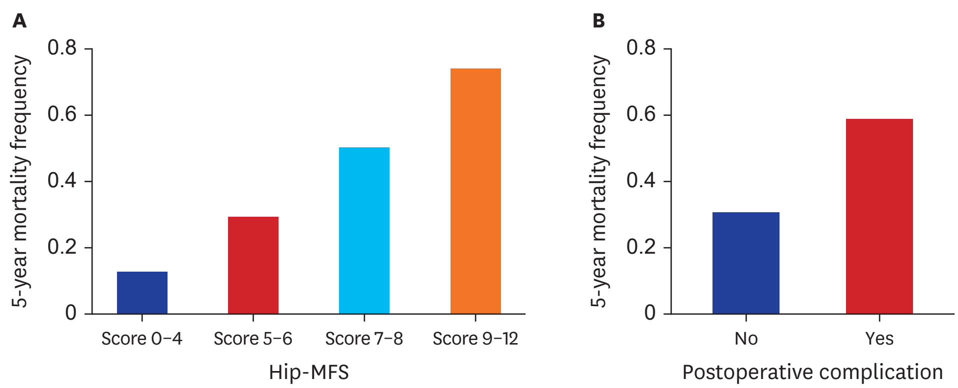

Fig. 1. Incidence of 5-year mortality. Incidence of 5-year mortality according to (**A**) the Hip-MFS and (**B**) postoperative complications.
Hip-MFS = Hip-Multidimensional Frailty Score.

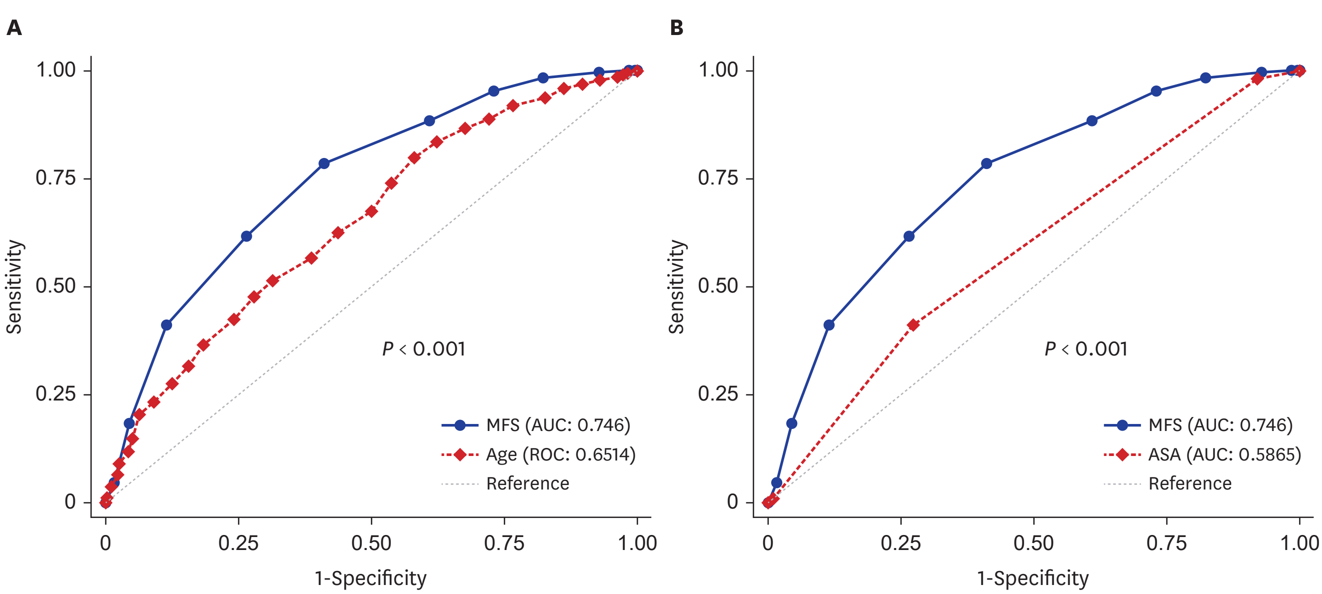

Fig. 2. Comparison of the area under the ROC curve for 5-year all-cause mortality. Comparison between Hip-MFS and (**A**) chronological age and (**B**) ASA classification.
ROC = receiver operating characteristic, Hip-MFS = Hip-Multidimensional Frailty Score, ASA = American Society of Anesthesiologists classification, AUC = area under curve.

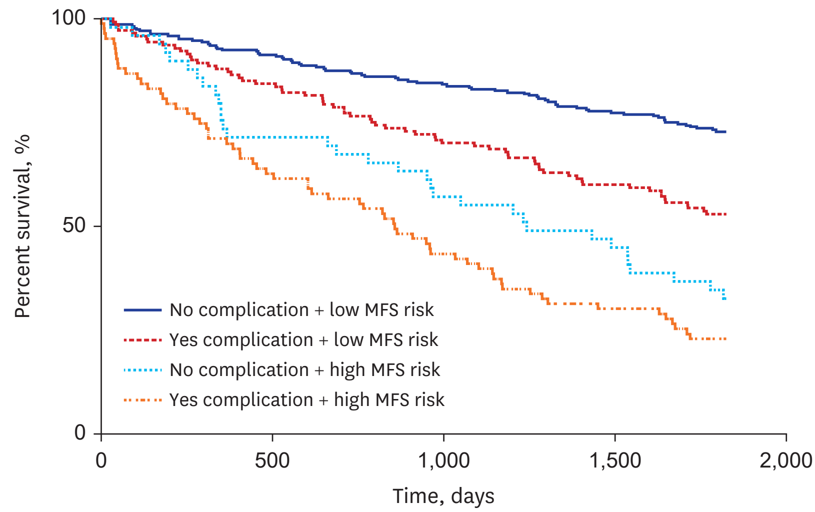

Fig. 3. Kaplan–Meier curve for 5-year mortality according to the Hip-MFS risk and postoperative complications. Hip-MFS = Hip-Multidimensional Frailty Score.

complications and a low-risk Hip-MFS (n = 264, 49.3%, black line) had the best prognosis. Patients who experienced postoperative complications but had a low Hip-MFS (n = 140, 26.1%, blue line) showed better 5-year survival than those without postoperative complications but had a high Hip-MFS (n = 49, 9.1%, green line) (P = 0.013) (**Fig. 3**).

DISCUSSION

Older frail patients, classified as having a high Hip-MFS risk, and patients who experienced postoperative complications during hospitalization were the major risk factors for 5-year all-cause mortality among patients with HF. Frailty and postoperative complications remained significant concerning mortality after adjusting for demographic and clinically relevant factors. The results of this study confirmed that the evaluation of the Hip-MFS is more helpful for predicting long-term prognosis than chronological age or the ASA classification. Frailty and postoperative outcomes showed an additive effect on 5-year all-cause mortality; however, frailty was a stronger risk factor than postoperative complications. The results of our investigation align with those of previous studies, thus confirming the prognostic role of frailty and postoperative complications after HF surgery. Postoperative complications can lead to increased short- and long-term mortality.[16,22] A previous meta-analysis showed that preoperative frailty might be associated with in-hospital mortality, 30-day mortality, and postoperative complications after HF surgery.[15]

Frailty increases the risk of postoperative complications, and the occurrence of postoperative complications increases the risk of 5-year mortality. However, even after adjusting for frailty and postoperative complications, there was a statistically significant increase in the risk of 5-year mortality.

The 5-year mortality rate in this study, 43.8%, aligns with previous research findings.[5,11] Additionally, the risk factors identified here were consistent with those in earlier studies, including older age; male sex; low BMI; anemia; elevated creatinine and low serum protein, albumin, or cholesterol levels; complicated comorbidities; dependency in ADL or IADL; risk

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of malnutrition; and poor cognitive function.[5,23] The Hip-MFS is a robust prognostic scoring system that incorporates multidimensional components to predict outcomes from short-term complications to long-term (5-year) all-cause mortality. Similarly, the Nottingham Hip Fracture Score (NHFS) evaluates factors such as age, sex, admission hemoglobin, cognitive state, comorbidities, and living situation.[23] In the present study, we assessed the usefulness of the Hip-MFS in predicting postoperative outcomes, and through univariate analysis, we found that components of previous scoring models such the NHFS also significantly predict outcomes.[23] Additionally, all the components of Hip-MFS, including sex, CCI, albumin, Koval grade, MMSE score, risk of falling, MNA, and mid-arm circumference, were statistically significant predictors of 5-year mortality (**Supplementary Table 1**).

Furthermore, we compared four scenarios to analyze which factor, frailty or postoperative complications, posed a greater risk of increasing the 5-year mortality. Ultimately, we found that there was an additive effect between postoperative complications and frailty, and it was evident that frailty was a more significant factor in increasing the risk of 5-year mortality than postoperative complications among patients who underwent HF surgery. Therefore, instead of targeting patients who experience postoperative complications, it is important to identify high-risk individuals through the assessment of preoperative frailty and provide interventions for postoperative complications and long-term survival. Our study also proves the superior prognostic utility of the Hip-MFS compared with that of a more subjective tool, the ASA classification or chronological age.

Our study has several strengths. Participants underwent CGA as assessed by a geriatrician, a geriatric advanced nurse practitioner, a dietitian, and a pharmacist. Therefore, we focused on the results obtained by highly credible assessors using reliable methods involving cognitive function, physical function, medical conditions, medication, and nutrition. Finding a cohort of patients with long-term follow-up observations along with detailed patient evaluations with HFs who underwent surgery is difficult. Assessing frailty before HF surgery and establishing perioperative and long-term management plans are essential.

However, our study has several limitations. First, it had a retrospective cohort design; hence, the assessment of postoperative complications was conducted using medical records. Additionally, data on the occurrence of postoperative complications after discharge could not be collected. However, the incidence of delirium in this study (36.2%) was comparable to that reported in a previous systematic review (10.09–51.28%).[24] Second, there might have been selection bias because we included patients with HFs who underwent CGA and excluded patients whose Hip-MFS data were missing. However, according to our previous research, no significant difference was observed between the baseline characteristics of the participants and non-participants.[8] Third, we used various statistical methods to compare the impact of frailty and postoperative complications on the 5-year mortality. However, because frailty is a risk factor for postoperative complications, caution is required when interpreting and applying the results in clinical practice regardless of statistical adjustments and significance.[8]

The Hip-MFS showed better prognostic power for 5-year mortality after HF surgery than chronological age and the ASA classification. Patients with postoperative complications or high Hip-MFS had an increased 5-year mortality risk. Even when compared with the occurrence of postoperative complications, the frailty status evaluated with the Hip-MFS had a more significant impact on long-term mortality after HF surgery. In conclusion, evaluating frailty prior to HF surgery, creating a comprehensive management plan for the perioperative period, and providing long-term care are crucial.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

The variables of the Hip-MFS associated with 5-year mortality according to Cox regression

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