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Hip Fractures in Centenarians: Functional Outcomes, Mortality, and Risk Factors from a Multicenter Cohort Study

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Background: Increasing longevity has caused the very old population to become the fastest-growing segment. The number of centenarians (over 100 years old) is increasing rapidly. Fractures in the elderly lead to excessive medical costs and decreased quality of life with socioeconomic burdens. However, little research has thoroughly examined the functional outcomes and mortality of hip fractures in centenarians.

Methods: This is a retrospective observational study. Sixty-eight centenarian hip fracture patients were admitted to the 10 institutions from February 2004 to December 2019. Fifty-six patients with 1-year follow-up were finally included. The following data were obtained: sex, age, body mass index, Charlson comorbidity index value on the operation day, Koval's classification for ambulatory ability, type of fracture, the time interval from trauma to surgery, American Society of Anesthesiologists grade, surgery-related complications, and duration of hospital stay. Postoperative Koval's classification (at 1 year after surgery) and information about death were also collected. Multivariate analysis was performed to analyze the risk factors affecting mortality 1 year after surgery.

Results: Mortality rates were 26.8% at 6 months and 39.3% at 1 year. The 90-day mortality was 19.6%, and one of them (2.1%) died in the hospital. The 1-year mortality rates for the community ambulatory and non-community ambulatory groups were 29% and 52%, respectively. Only 9 (16.1%) were able to walk outdoors 1 year after surgery. The remaining 47 patients (83.9%) had to stay indoors after surgery. Multivariate analysis demonstrated that the pre-injury ambulatory level (adjusted hazard ratio, 2.884; $p = 0.034$) was associated with the risk of mortality.

Conclusions: We report a 1-year mortality rate of 39.3% in centenarian patients with hip fractures. The risk factor for mortality was the pre-injury ambulatory status. This could be an important consideration in the planning of treatment for centenarian hip fracture patients.

Keywords: *Hip fracture, Centenarian, Treatment outcome, Mortality*

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In most developed countries, increasing longevity has caused the very old population to become the fastest-growing segment. The number of centenarians (over 100 years old) is increasing rapidly. In the United States, the number of centenarians increased by 65.8% between 1980 and 2010, almost doubling the total population increase.[1] And a global increase from almost half a million centenarians in 2015 to between 13 and 50 million is estimated during the 21st century.[2]

A hip fracture is a serious injury that commonly occurs in elderly patients. The risk factors for falls in the elderly population, such as impaired balance, polypharmacy, the use of assistive devices, and cognitive impairment, also increase the risk of hip fractures.[3] The prevalence of hip fractures is steeply increasing in elderly people, such as centenarians. Hip fractures in the aging population are a major concern for the healthcare system and are related to high mortality and morbidity. Such fractures also lead to excessive medical costs and decreased quality of life with socioeconomic burdens.[4,5]

The first-year mortality after hip fracture was reported to be 30%–60% in previous centenarian studies.[6-8] Other studies reported higher mortality rates and complications in centenarians compared to those in patients aged 70–80 years.[9,10] The mean number of complications was the risk factor most consistently related to in-hospital and post-discharge mortality.[11] However, little research has thoroughly examined the functional outcomes and mortality of hip fractures in centenarians. This is likely due to the small sample size of patients who live to this advanced age and the difficulty in following up with such extremely old patients for a long time after surgery. As such, the sample size of the existing studies is very small, ranging from 13 to 33 cases.[7,8,11] The purpose of this study was to investigate the characteristics of hip fractures, mortality, and functional outcomes and assess the risk factors for mortality in centenarians.

METHODS

This is a retrospective observational study involving 10 institutions. Patient data were retrospectively investigated through a chart review of patients' medical records at each institution. Institutional Review Board approval for this retrospective study was obtained from Soonchunhyang University Gumi Hospital (No. 2023-01), and informed consent was waived. Sixty-eight centenarian hip fracture patients were admitted to the 10 institutions from February 2004 to December 2019. One patient died before surgery, and five patients did not consent to surgery. Six patients were lost to follow-up, and 22 patients died during the follow-up period after surgery (Fig. 1).

The following data were obtained by reviewing medication records: sex, age, body mass index (BMI), Charlson comorbidity index value on the operation day, Koval's classification for ambulatory ability, type of fracture, the time interval from trauma to surgery, American Society of Anesthesiologists (ASA) grade, type of anesthesia, type of surgery, intraoperative blood loss, surgery-related complications, and duration of hospital stay. Hospital readmissions, postoperative Koval's classification (at 1 year after surgery), and death information (date of death and cause of death) were also collected. Ambulatory status was divided into community ambulatory (Koval's classification I–III) and non-community ambulatory (Koval's classification IV–VII) groups.

Routine follow-up visits were scheduled for 6 weeks, 3, 6, 9, and 12 months, and every year thereafter. Patients who were unable to attend follow-up evaluations were contacted by one orthopedic surgeon (BWJ) for telephone interviews with the patient's family to evaluate recent conditions.

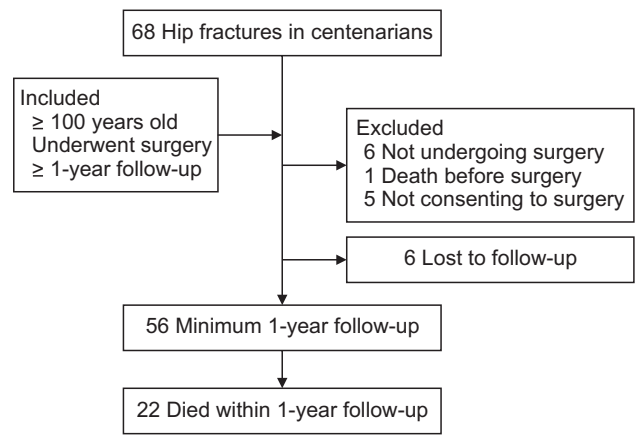

Fig. 1. Flowchart of inclusion and exclusion criteria.

Statistical Analysis

In-hospital mortality and mortality rates at 90 days, 6 months, and 1 year after centenarian hip fracture surgery were analyzed. The chi-square test or Fisher's exact test was used for categorical variables, and Student *t*-test or analysis of variance was used for continuous variables. A *p*-value < 0.05 was used to determine statistical significance. Multivariate analysis using Cox's proportional hazards regression model was performed to analyze the risk factors affecting mortality 1 year after surgery. Kaplan-Meier time analysis was used to estimate survival after surgery in the community and non-community ambulatory groups. Statistical analyses were performed using IBM SPSS ver. 25.0 (IBM Corp., Armonk, NY, USA).

Table 1. Demographics of Centenarian Hip Fracture Patients (56 hips)

Variable	Value
Sex (male : female)	12 : 44
Age (yr)	101.8 ± 1.64
BMI (kg/m^2)	20.2 ± 4.42
Charlson comorbidity index	
4	13 (23.2)
5	15 (26.8)
6	19 (34)
7	9 (16)
≥ 8	0
Koval's classification	
Community ambulatory (I–III)	31 (55.4)
Non-community ambulatory	
Household ambulatory (IV–VI)	2 (3.5)
Nonfunctional ambulatory (VII)	23 (41.1)
Fracture type	
Intertrochanteric	38 (67.9)
Femoral neck	18 (32.1)
Time to surgery (day)	4.6 ± 4.31
ASA grade	
1	3 (5.4)
2	25 (44.6)
3	25 (44.6)
4	3 (5.4)
Type of anesthesia	
General	18 (32.1)
Regional	38 (67.9)
Type of surgery	
Internal fixation	42 (75)
Hemiarthroplasty	14 (25)
Blood loss (mL)	294.6 ± 144.16
Hospital stay (day)	26.7 ± 14.2

Values are presented as mean ± standard deviation or number of hips (%).
BMI: body mass index, ASA: American Society of Anesthesiologists.

RESULTS

Characteristics of Centenarian Patients with Hip Fractures

Of the 56 patients with 1-year follow-up, 12 were male, and 44 were female. Their mean age was 101.8 ± 1.64 years. Thirty-one patients (55.4%) were able to walk outdoors (community ambulatory group) before the injury, and 25 patients (44.6%) were unable to walk outdoors (non-community ambulatory group). Thirty-eight (67.9%) had intertrochanteric fractures and 18 (32.1%) had femoral neck fractures. Internal fixation was performed in 42 patients (75%), and hemiarthroplasty was performed in the remaining 14 patients (25%) (Table 1). Hypertension was the most common comorbidity seen in 59% of all patients, followed by dementia (16.1%), atrial fibrillation (12.5%), and diabetes mellitus (9%) (Table 2).

Table 2. Preoperative Medical Comorbidities

Comorbidity	Number of patients (%)
Hypertension	33 (59.0)
Dementia	9 (16.1)
Atrial fibrillation	7 (12.5)
Diabetes mellitus	5 (9.0)
Chronic obstructive lung disease	5 (9.0)
Gastrointestinal disease	5 (9.0)
Cerebrovascular accident	3 (5.4)
Angina pectoris	3 (5.4)
Renal disease	3 (5.4)
Uterine cancer	1 (1.8)
Liver cirrhosis	1 (1.8)

Table 3. Mortality Rates after Surgery in Centenarian Hip Fracture Patients

Mortality	Overall (n = 56)	Community ambulatory group (n = 31)	Non-community ambulatory group (n = 25)	*p*-value
In hospital	1 (2.1)	1 (3.2)	0	0.000
90 Days	11 (19.6)	5 (16.1)	6 (24)	0.267
6 Months	15 (26.8)	6 (19.4)	9 (36)	0.112
1 Year	22 (39.3)	9 (29)	13 (52)	0.083

Values are presented as number (%).

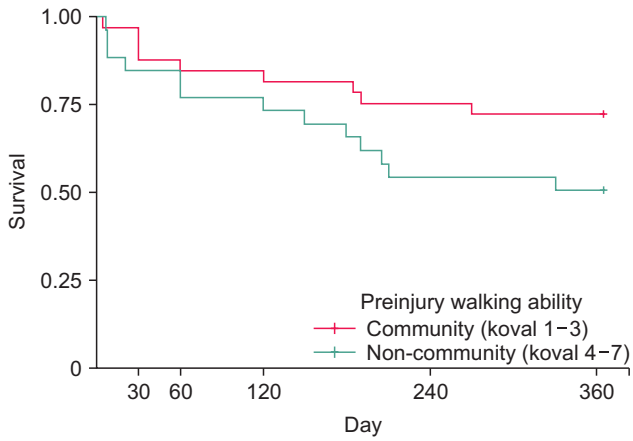

Fig. 2. Kaplan-Meier survival curve of centenarian hip fracture patients after surgery.

Table 4. Pre- and Postoperative (1-Year Follow-up) Ambulatory Ability in Koval's Classification

Koval's classification	Preoperative	Postoperative
Community ambulatory (I–III)	31 (55.4)	9 (16.1)
Non-community ambulatory		
Household ambulatory (IV–VI)	23 (41.1)	25 (44.6)
Nonfunctional ambulatory (VII)	2 (3.5)	22 (39.3)

Values are presented as number of hips (%).

Mortality and Functional Outcomes

Sixteen patients (28.6%) completed 1-year follow-ups by visiting the hospital. We were able to collect data on ambulatory functional outcomes and mortality in the remaining 40 patients (71.4%) through telephone interviews with their families. Mortality rates were 26.8% at 6 months and 39.3% at 1 year. The 90-day mortality was 19.6%, and one of them (2.1%) died in the hospital. The 1-year mortality rates for the community ambulatory and non-community ambulatory groups were 29% and 52%, respectively (Table 3). Of the 22 patients who died during the 1-year follow-up, 9 patients (40.9%) died between 4 and 7 months after surgery (Fig. 2).

Thirty-one (55.4%) patients were able to walk outdoors before their injury. However, only 9 (16.1%) were able to walk outdoors 1 year after surgery. The remaining 47 patients (83.9%) had to stay indoors after surgery (Table 4).

Risk Factors for 1-Year Mortality

Logistic regression was performed to ascertain the effects of age, BMI, comorbidities, Koval's classification, fracture type, time to surgery, ASA grade, type of anesthesia, type of surgery, blood loss, and hospital stay on the odds of 1-year mortality (Table 5).

Multivariate analysis using Cox's proportional hazards regression model demonstrated that the pre-injury ambulatory level (Koval's classification, adjusted hazard ratio [HR], 2.884; 95% confidence interval [CI], 0.866–9.598; $p = 0.034$) and age (adjusted HR, 0.820; 95% CI, 0.584–1.152; $p = 0.254$) were associated with the risk of mortality in centenarians after hip fracture surgery. The impact of the pre-injury ambulatory level on 1-year mortality was statistically significant (Table 6).

Six patients did not undergo surgery. One patient died before surgery within 10 days of admission due to hypovolemic shock. The remaining 5 patients were transferred to another hospital because they did not consent to surgery. All patients who were transferred to another hospital without surgery died within 4 months due to the exacerbation of hypovolemic shock, pneumonia, and cholangitis. Two patients had second hip fractures after surgery. A Vancouver type AL periprosthetic fracture occurred in 1 patient but was treated with observation without surgery. Superior and inferior pubic ramus fractures occurred in the other patient and healed in 3 months. There were no cases of readmission due to other problems.

Table 5. Crude HR of Multiple Parameters for 1-Year Mortality in Centenarian Patients with Hip Fractures

Parameter	Crude HR	95% CI	*p*-value
Age	0.800	0.565–1.133	0.209
BMI	0.980	0.858–1.120	0.771
CCI	0.949	0.555–1.621	0.848
Koval's classification	2.884	0.866–9.598	0.084
Fracture type	0.646	0.205–2.036	0.455
Time to surgery	0.964	0.845–1.100	0.591
ASA grade	1.460	0.640–3.329	0.368
Type of anesthesia	0.838	0.222–3.162	0.794
Type of surgery	0.510	0.112–2.331	0.385
Blood loss	1.000	0.997–1.003	0.836
Hospital day	0.971	0.926–1.018	0.221

HR: hazard ratio, CI: confidence interval, BMI: body mass index, CCI: Charlson comorbidity index, ASA: American Society of Anesthesiologists.

Table 6. Multivariate Cox Proportional Hazard Regression Analysis for Risk of Mortality

Parameter	Adjusted HR	95% CI	*p*-value
Age	0.820	0.584–1.152	0.254
Koval's classification	2.884	0.866–9.598	0.034

HR: hazard ratio, CI: confidence interval.

DISCUSSION

The concern for mortality after hip fracture in elderly patients has been long-standing. In previous studies, people over 80 years were also considered to be in a special age group. Choi et al.[12] reported that patients with lung disease, females, and delays in surgery were risk factors for mortality. Next, research was conducted on nonagenarians. Nonagenarian studies generally had sufficient sample sizes,[13-15] and some studies analyzed large databases.[16] Previous studies that examined nonagenarian patients with hip fractures found high rates of in-hospital complications (52%) and mortality at 24 months (49%), as well as long hospital stays.[17] The 1-year mortality rate of nonagenarian patients with hip fractures was 23.4 to 29.9%.[11,15] Higher mortality rates in nonagenarians than younger patients have been reported to be associated with more comorbidities, poorer pre-fracture functional status, and more medical complications.[18,19]

There has been interest in the outcomes of anesthesia and surgery in people 100 years of age and older. According to a study by Warner et al.[6] in 1998, the 1-year mortality was reported to be 35.5% for all types of surgery in centenarians. Although the number of samples was very small, the 1-year mortality rate of hip fractures was reported to be 22% (2 out of 9 patents). The maximum human lifespan is thought to be about 115 years.[20] The incidence of hip fractures in centenarians is about 4%, which is about 7 times higher than that of other age groups.[21] According to Tarity et al.,[7] the 90-day mortality of 21 patients who underwent surgery was 30%. Several studies reported a 1-year mortality rate of approximately 60% in centenarian patients.[11,22] In our study, the 90-day mortality rate was 19.6%, and the 1-year mortality rate was 39.3%, which were lower than those of previous studies. It is difficult to explain precisely why the mortality rates in this study were lower than those of other studies. However, the subjects in this study had fewer medical heart, kidney, and liver comorbidities compared to those in other studies. And in a large number of patients (75%), the less invasive surgical method of internal fixation was chosen. We speculate that the mortality rates in this study were relatively low for these reasons.

The 1-year mortality of 39.3% in centenarian hip fracture surgery in this study was not significantly different from that of nonagenarians previously reported. Mosfeldt et al.[22] reported that centenarian patients had fewer comorbidities than a younger comparison group (70–99 years). Comorbidities, rather than age itself, are thought to affect mortality from a hip fracture. And people who lived to be over 100 years of age were probably medically healthy at the time of fracture. It is difficult to assess the risk factors for mortality at extremely old ages. Studies have used a large database on centenarian hip fracture patients, but most of them reported only short-term outcomes, and it was difficult to analyze functional outcomes and risk factors for mortality due to the limitations of database-based research.[22,23] The strength of our study is that it reported the results of 1-year follow-ups and analyzed the risk factors for death in hip fracture patients aged 100 years or older. Kim et al.[15] reported that the risk factors for mortality in nonagenarians with hip fractures were ASA scores and the time interval from trauma to surgery. Chung et al.[24] reported that more than three underlying disease and inactivity were risk factors that increased mortality after osteoporotic hip fractures. According to the results of our study, the patient's ambulatory level influenced the 1-year mortality in centenarian patients, rather than ASA scores or time to surgery. Patients who were unable to walk outdoors had a HR of 2.884 for 1-year mortality compared to patients who could walk outdoors.

Only about 40% of hip fracture patients return to their pre-injury level of walking.[25,26] Only half of the patients who had been able to walk outdoors before the fracture could do so afterward.[27] Although the sample size was not sufficient, a previous study targeted ambulatory outcomes in centenarian hip fracture patients: operative management resulted in 83% of the patients (5 out of 6) achieving ambulation versus only 25% of the patients with conservative treatment (1 out of 4) who were previously ambulatory with or without a walking aid.[28] In our study, only 29% of the centenarian patients (9 out of 31) who had been able to walk outdoors before the fracture could do so at the last follow-up after hip fracture surgery, and the remaining 47 patients (83.9%) had to stay indoors. Most of the centenarian hip fracture patients could not return to their pre-injury walking state and stayed indoors. Therefore, an active gait rehabilitation program is required, even in extremely old hip fracture patients, and the establishment of a patient care system at home is also needed.

There are a few limitations of this study. As this is a retrospective study, there is a risk of inaccuracy in the process of coding the data. And most of the information was collected through telephone interviews because in many cases it was impossible for patients to follow-up with hospital visits due to difficulty in mobility. In addition, since this study only targeted patients who underwent surgery, it is difficult to understand the nature of the centenarian hip fracture patients who did not undergo surgery. Lastly, there is a possibility of selection bias. Only healthy patients expected to have good results may have undergone surgery; thus, the results reflect their surgical outcomes, not the overall surgical outcome of the patients.

In conclusion, we report a 1-year mortality rate of 39.3% in centenarian patients with hip fractures. The risk factor for mortality was the pre-injury ambulatory status. Patients who ambulated only indoors before fracture had high 1-year mortalities compared to those who could walk outdoors. This could be an important consideration in the planning of treatment for centenarian hip fracture patients.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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