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Original Article

Visual Impairment, Partially Dependent ADL and Extremely Old Age Could be Predictors for Severe Fall Injuries in Acute Care Settings

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SUMMARY

Background: Severe fall injuries in inpatients extend hospital stay, increase medical costs, and shorten patients' healthy life expectancy. The objective of this study was to clarify the predictors for severe fall injuries requiring treatments of inpatients in acute care settings.
Methods: We retrospectively analysed adult inpatients who suffered falls in an acute care hospital in Kyushu, Japan from April 2012 to January 2015. Using hospital record data, we compared patients who had required treatments after falls with those who had not by univariate and multivariate analyses.
Results: Among 371 patients who suffered falls, the median age was 83 years (interquartile range: 78–87 years). Fall required treatments in 46 patients (12%). In those required treatments, univariate analysis revealed higher percentages of patients with visual impairment (OR: 4.1, 95%CI: 1.3–12.8, $p = 0.023$) and a bedriddenness rank of A (partial dependence with housebound status) (OR: 2.4, 95%CI: 1.3–4.5, $p = 0.006$) as well as patients aged ≥85 years (OR: 1.9, 95%CI: 1.0–3.6, $p = 0.039$). There were lower percentages of patients with a cognitive function score of 4 (requiring constant assistance with symptoms interfering with daily activities) ($p = 0.008$). In multivariate analysis, age of ≥85 years (OR: 2.2, 95%CI: 1.1–4.2, $p = 0.021$), visual impairment (OR: 4.2, 95%CI: 1.3–13.9, $p = 0.019$), and a bedriddenness rank of A (OR: 2.4, 95%CI: 1.3–4.7, $p = 0.009$) were associated with falls requiring treatment.
Conclusion: Visual impairment, partial dependence in activities of daily living and 85 years of age or older could be useful predictors for severe fall injuries.

1. Introduction

Falls during hospitalisation are unfortunate events not only for patients but for their families, medical personnel, and society as well. Patients can be forced to limit their activity because of the pain of injuries caused by falling or because of the fear of falling,[1] which diminishes their ability to engage in activities of daily living (ADL)[2,3] and then can lead to disuse syndrome. Fall events in hospitals can result in lawsuits because of families' resentful feelings toward medical personnel.[4] Furthermore, preventing falls is important from an economic perspective because additional costs incurred because of fall injuries can be extremely high. Previous reports in Japan have shown that these extra medical costs vary greatly depending on the severity of fall injuries.[5] The cost of treating fall injuries in the United States has increased alongside the aging of patients.[6]

Associations between falls and various factors such as lower scores for ADL and muscle weakness or cognitive function decline have been reported.[7] Various other factors have also been shown in previous reports to be related to severe fall injuries; syncope, history of fall injury, visual impairment,[8] family history of maternal hip fracture, use of long-acting benzodiazepine, hyperthyroidism, use of anti-epilepsy drugs, excessive caffeine intake, walking less than 4 hours a day,[9] inability to get up from lying on the floor, rheumatic disorders, having experienced more than one fall, cognitive impairment[10] or executive function impairment.[11,12]

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These studies were performed among community-dwelling older adults. On the other hand, vertigo, weakness of the legs and having cancer were reported to relate to severe fall injuries in the elderly inpatients, which was not strictly limited to acute settings.[13]

Because human and physical resources to prevent falls in inpatients are limited in most hospitals in Japan, they should be preferentially supplied for candidates with higher risks of severe fall injuries that would require some kind of devoted and expensive treatments. Here, we report the predictive factors of severe fall injuries among inpatients in the setting of acute care.

2. Patients and methods

2.1. Study design, patients, and setting

This is a retrospective cohort study. We analysed 371 falls of consecutive adult inpatients 20 years of age or older (Fig. 1) who were admitted to an acute care hospital from April 2012 to January 2015. The falls were identified from incident reports. The hospital consists of 10 departments including internal medicine, general surgery, and cardiovascular surgery with 111 beds, located in a small city (population approximately 90,000) in Kyushu, southern Japan. The hospital treated over 3,000 patients as inpatients per year, as of 2014.

2.2. Data sources and measures

The data were derived from the available hospital's health records to review retrospectively, including admission assessments of age (≥85 years of age or not), sex (male or female), department to which the patient was admitted (Department of Internal Medicine, Neurosurgery, or other), emergency admission (or not emergency), whether the patient was transferred by ambulance, ADL (independent or not), Japan Ministry of Health, Labour and Welfare (MHLW) bedriddenness rank (Normal, J: independence/autonomy, A: house-bound, B: chair-bound and C: bed-bound) and cognitive function (Normal, 1, 2, 3, 4 and M) in daily living (Supplement 1),[14] use or non-use of hypnotics defined as both benzodiazepine and non-benzodiazepine types of sleep-inducing medications including zolpidem, zopiclone and eszopiclone, use or non-use of a wheelchair, possession or lack of referral letter from a primary physician, presence or absence of residual permanent damage from stroke, presence or absence of visual impairment, presence or absence of Parkinsonism, and history of falls (or lack thereof). Most of the variables that we chose were recognized as risk factors of fall or fall injury in community-based prospective cohort studies; age, female gender, cognitive impairment, psychotropic drug use, history of stroke, Parkinsonism, visual impairment and limitations in ADL.[7,8,10–12] The other variables we chose were not generic risk factors but the factors that showed a significant difference between patients with and without falls in our preceding study (unpublished data). These were referral medical letter, the department to which they were admitted, emergency admission status, whether transferred by ambulance, and use of a wheelchair. All these data were routinely recorded before or immediately after their admission to prevent falls and expedite discharge.

We use the classifications for abilities of daily living advocated by the MHLW, including the bedriddenness rank and cognitive function score, because those classifications are widely used[15,16] in the process of public certification of long-term care need in Japan (Supplement 1)[14] and can be assessed easily.

The variables associated with ADL in patients assessed by nurses as having some difficulties in daily living or communications were checked manually on admission. Those of the patients unchecked by the nurses were treated as normal or independent. Although the individual degree of "visual impairment" was not concretely assessed in this retrospective chart study, the attending nurses evaluated whether the disorder impaired their activities in daily living.

Information regarding fall events, including the severity of incidents (levels 0, 1, 2, 3a, 3b, 4a, 4b, and 5) (Supplement 2),[16] the time of the fall (6:00–8:59, 9:00–16:59, 17:00–21:59, and 22:00–5:59) and the reasons for the fall (patient's health problems, side effects of examinations or therapies, environmental conditions, and other factors) were recorded by the nurses in charge of the patient or the medical safety manager within a few days after falling.

The severity scale for incidents/accidents including fall accidents advocated by the Medical Safety Control Council of National University Hospital is widely used to evaluate the severity of incidents and accidents, including fall events, occurring in hospitals in Japan (Supplement 2).[17]

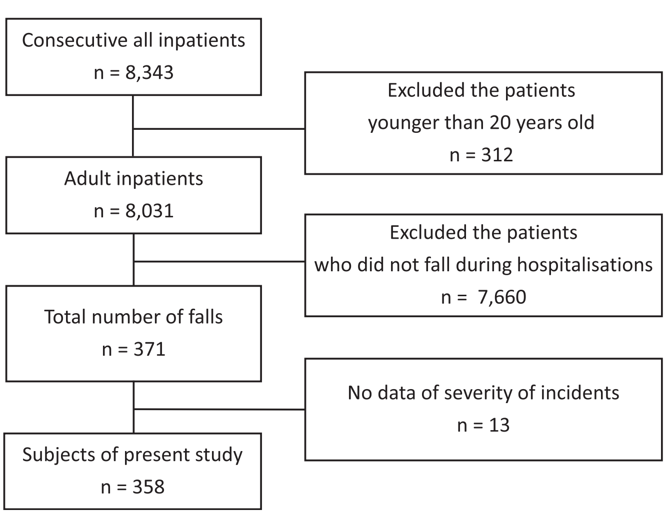

Fig. 1. Data flow diagram of this study.
We analysed 371 falls of consecutive adult inpatients 20 years of age or older.

2.3. Data analysis

Patients who fell in the hospital were divided into two groups: those with an injury severity level of 3 or higher (Treatment group) and those with a level lower than 3 (Treatment-free group). In univariate analysis (chi-squared test), we compared the proportion of the presence of each factor such as 85 years of age or older, bedriddenness rank A or cognitive function score 1 between in the treatment group and treatment-free group. Items with significant differences in the univariate analysis were analysed by binomial logistic regression analysis. All calculations were performed using IBM SPSS Statistics for Macintosh, version 23.0.0 (IBM Corp., Armonk, NY). Statistical significance was set at $p < 0.05$.

2.4. Ethical consideration

This study was approved by the research ethical committee of Yuai-kai Foundation & Oda hospital and adhered to the Principles of the Helsinki Declaration. Patients provided informed consent, and anonymity was protected.

3. Results

The number of inpatients during the research period was 8,343, of whom 8,031 were aged 20 years or older, and a total of 371 falls occurred. The severity levels of the incidents and accidents were available in 358 falls. The median length of hospital stay among adult inpatients including patients who did not fall was 9 days, and the incidence density of falls was 3.27 per 1,000 patient-days (Table 1). The median age of patients who fell was 83 years, and the median length of hospital stay was 27 days. Bedriddenness ranks were normal, J, A, B, and C in 9%, 10%, 32%, 28%, and 19% of patients who fell, respectively. Cognitive function scores of normal, 1, 2, 3, 4, and M were found in 27%, 20%, 24%, 16%, 10%, and 2% of fall patients, respectively. The number of falls in the periods 6:00–8:59, 9:00–16:59, 17:00–21:59, and 22:00–5:59 was 54 (18 falls per hour), 83 (10 falls per hour), 68 (14 falls per hour), and 151 (19 falls per hour), respectively. Falls caused by patients' health problems accounted for 72%. The numbers (percentages) of patients with injury severity levels of 1, 2, 3a, and 3b were 188 (51%), 124 (33%), 35 (9%), and 11 (3%), but no falls with injury levels of 4 or 5 occurred (Table 1).

The result of univariate analysis among 358 patients is shown in Table 2. According to the chi-squared test, the proportions of patients 85 years of age or older (Odds ratio [OR]: 1.9, 95% confidence interval [CI]: 1.0–3.6, $p = 0.039$), with visual impairment (OR: 4.1, 95%CI: 1.3–12.8, $p = 0.023$), independent toileting (OR: 2.1, 95%CI: 1.0–4.4, $p = 0.048$), bedriddenness rank of A (OR: 2.4, 95%CI: 1.3–4.5, $p = 0.006$) and hospital stay shorter than 27 days (OR: 2.2, 95%CI: 1.2–4.3, $p = 0.017$) were higher in the treatment group, and there were lower percentages of patients with a cognitive function score of 4 (OR: 0.9, 95%CI: 0.9–0.9, $p = 0.008$) in the treatment group. Jonckheere-Terpstra trend test between severity and age as continuous variable ($p = 0.276$), and bedriddenness rank ($p = 0.161$) and cognitive function score ($p = 0.456$) as ordinal variables did not show significant trend.

The results of multivariate analysis are shown in Table 3. Multivariate analysis was conducted with five items (85 years of age or older, visual impairment, independence of toileting, bedriddenness rank of A, a cognitive function score of 4), which were available on admission and showed significant differences with the univariate analysis. Binomial logistic regression analysis with forced entry showed significant associations between 85 years of age or older (OR: 2.2, 95%CI:1.1–4.2, $p = 0.021$), and visual impairment and falls causing injury (OR: 4.2, 95%CI: 1.3–13.9, $p = 0.019$) and between bedriddenness rank of A and falls causing injury (OR: 2.4, 95%CI: 1.3–4.7, $p = 0.009$) in the treatment group.

4. Discussion

This study clarified that 85 years of age or older, visual impairment, and bedriddenness rank of A could be independent predictors for severe fall injuries among inpatients in an acute care setting. The proportion of elderly who had fallen has been increased.[18] Prevention of falls is important from an economic perspective because the extra costs incurred as a result of fall injuries occurring during hospitalisation could be extremely high. These additional medical costs vary greatly depending on the severity of the fall injury: a mild injury of level 2 costs an average of 10,070 yen per patient fall; a moderate injury of level 3a costs an average of 12,859 yen; and a severe injury of level 3b costs an average of 226,723 yen.[5] It is reasonable to assume that preventing more severe fall injuries would have a much larger impact than preventing milder injuries occurring in hospital inpatients. In addition, although bone fractures associated with falls were classified as severity event level 3b, in falls with severe but only temporary disability, fractures were reportedly factors in the deterioration of ADLs that increased the level of care needed for elderly people. Therefore, it is also crucial to pay careful attention to evaluating the presence of bone fractures immediately after a fall occurs.

Because most elderly patients have diminished vestibular function, which makes those patients more dependent on visual information, the presence of visual impairment has greater clinical importance in aged patients. Assuming a defensive position is much more difficult for patients suffering from visual impairment, which leads to severe injuries from falls in such patients.[19,20]

The degree of impairment of ADLs in the bedriddenness rank of A is mild. The relationship between falls and disabilities in activities of daily living such as gait disorder has been shown in a few previous reports.[7,21] On the other hand, there is a report asserting that being physically active related to multiple falls,[22] which is seemingly contradictory but understandable. Patients with a bedriddenness rank of A are defined as having the ability to stand independently but unable to go outside without assistance. This

Table 1
Background information on inpatients and falls.

All inpatients		
Number	8,031	patients
Median length of hospitalisation (interquartile)	9 (5 to 17)	days
Median age (interquartile)	77 (63 to 85)	years
The incidence density of the severity level of falling among all inpatients ($n = 8,031$)		
level 1 ($n = 188$)	1.65	falls per 1,000 patient-day
level 2 ($n = 124$)	1.09	falls per 1,000 patient-day
level 3a ($n = 35$)	0.31	falls per 1,000 patient-day
level 3b ($n = 11$)	0.10	falls per 1,000 patient-day
Unknown level ($n = 13$)	0.11	falls per 1,000 patient-day
Total ($n = 371$)	3.27	falls per 1,000 patient-day
Patients suffering from falls ($n = 371$)		
Median length of hospitalisation (interquartile)	27 (15 to 53)	days
Median age (interquartile)	83 (78 to 87)	years
The number and proportion of the severity level of falling among falls ($n = 371$)		
level 1	188 (51%)	
level 2	124 (33%)	
level 3a	35 (9%)	
level 3b	11 (3%)	
Unknown level	13 (4%)	

SD: standard deviation.

Table 2
The results of univariate analysis of chi-square test.

Factor	Severity of fall injury		p value
	1–2 (n = 312)	3a–3b (n = 46)	
65 years of age or older	290 (93%)	43 (93%)	1.000
75 years of age or older	252 (81%)	39 (85%)	0.685
85 years of age or older	125 (40%)	26 (57%)	0.039
Women	163 (52%)	27 (59%)	0.433
Emergency admission	269 (87%)	40 (87%)	1.000
By ambulance	55 (18%)	4 (9%)	0.141
Presence of referral medical letter	18 (39%)	114 (37%)	0.745
Hypotonic	66 (21%)	10 (22%)	1.000
Permanent damage of stroke	31 (10%)	2 (4%)	0.284
Past history of falls	75 (24%)	14 (30%)	0.363
Visual impairment	9 (3%)	5 (11%)	0.023
Parkinsonism	2 (1%)	1 (2%)	0.339
Using wheelchair	23 (7%)	4 (9%)	0.764
Department of admission			
Internal medicine	190 (61%)	31 (67%)	0.516
Neurosurgery	35 (11%)	2 (4%)	0.198
Independence			
eating	240 (77%)	39 (85%)	0.259
swallowing	276 (88%)	42 (91%)	0.802
toileting	197 (63%)	36 (78%)	0.048
bathing	161 (52%)	28 (61%)	0.270
taking prescription drug	160 (51%)	29 (63%)	0.156
transferring	192 (62%)	33 (72%)	0.195
Bedriddenness rank			
Normal	29 (9%)	4 (9%)	1.000
J: independence/autonomy	30 (10%)	6 (13%)	0.437
A: house-bound	91 (29%)	23 (50%)	0.006
B: chair-bound	93 (30%)	8 (17%)	0.113
C: bed-bound	65 (20%)	5 (11%)	0.161
Disability to move	5 (2%)	0 (0%)	1.000
Cognitive function score			
Normal	87 (28%)	12 (26%)	0.862
1	59 (19%)	13 (28%)	0.167
2	70 (22%)	15 (33%)	0.140
3	54 (17%)	4 (9%)	0.197
4	36 (12%)	0 (0%)	0.008
M	7 (2%)	2 (4%)	0.325
Hospital stay shorter than 27days	149 (48%)	31 (67%)	0.017
Without operation	57 (18%)	9 (20%)	0.839
The time of fall			
Morning 6:00 to 8:59	49 (16%)	5 (11%)	0.510
Daytime 9:00 to 16:59	75 (24%)	8 (17%)	0.355
Evening 17:00 to 21:59	61 (20%)	7 (15%)	0.552
Night 22:00 to 5:59	125 (40%)	26 (57%)	0.054
The reason of the fall			
patient's health problems	236 (76%)	37 (80%)	0.549
examinations or therapies	23 (7%)	3 (5%)	1.000
environment	26 (8%)	2 (4%)	0.555
others	12 (4%)	2 (4%)	0.699

ability to remain standing independently results in patients with a bedriddenness rank of A suffering more severe injuries from falling than patients with bedriddenness ranks of B or C, who are unable to stand. This is because the impact of falling is much more severe when falling from an upright position than from a sitting position.

Subjects with bedriddenness ranks of normal and J have better (and, in fact, almost normal) physical abilities than those with the rank of A. This diminished physical ability in those with a rank of A makes it difficult or impossible for them to smoothly and adequately take a defensive position in falling episodes, which results in their injuries from falls being far more severe than those with the ranks of normal and J. Although Bedriddenness rank still has not been evaluated as a predictor for severe fall injuries, it could be very useful for predicting severe fall injuries in patients during hospitalisation because it is widely used in Japan for evaluating the ability of elderly patients. Furthermore, it is easy to use and widely utilised mainly by nurses in Japan.

Table 3
The result of Multivariate analysis of Binomial logistic regression analysis with forced entry.

Factor	Odds ratio	95% CI	P value
85 years of age or older	2.2	1.1–4.2	0.021
Visual impairment	4.2	1.3–13.9	0.019
Independent toileting	2.0	0.9–4.2	0.089
Bedriddenness rank of A	2.4	1.3–4.7	0.009
Cognitive function score of 4	0	0–	0.998

CI: confidence interval.

The present study has several limitations. This was a retrospective cohort study. There could be unavailable data because of the possible, unintended exclusion by medical personnel, though the hospital made it a rule to evaluate all the admitted patients before or immediately after their admission. Some of these unexamined factors might have influenced the severity of fall injuries. Because the bedriddenness rank, cognitive function in daily living scores, history of falls, visual impairment and incident severity scale were determined by attending nurses, the accuracy of these evaluations could not be completely verified. The target population of the present study is the inpatients who could have higher risk of fall during their hospitalisations in Japan, which is the leading country of aging society in the world. In addition, highly developed health insurance system covering universally in Japan might influence the results of this research, which let Japanese people visit hospitals more frequently (12.8 per a year), lower the cost of hospital visit (86 US-dollars per visit) and make the admission period longer (16.5 day).[23]

5. Conclusions

Visual impairment, a bedriddenness rank of A and 85 years of age or older could be useful predictors for severe injuries caused by falls. Among patients at high risk of falls, stronger and preferential precautions against falls or severe fall injuries are necessary for patients with visual impairment and a bedriddenness rank of A.

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Conflicts of interest

The authors declare no Conflict of Interests for this article.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ijge.2018.02.014.

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