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Predictors of Fall-related Injuries among Community-dwelling Elderly People with Dementia

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Summary

To determine the annual incidence of fall-related injuries among community-dwelling elderly people with dementia and to identify the factors predicting those likely to sustain such injuries, we conducted a cohort study with a one-year follow-up. As predicting factors, we paid particular attention to behavioural problems and difficulties in helping with activities of daily living based on the Assessment of Basic Care for the Demented (ABCD) scale. Thirty-five of 86 final study subjects and nine of 98 final control subjects sustained fall-related injuries. Significant factors associated with fall-related injuries to demented elderly subjects were ABCD score (adjusted odds ratio 0.73, 95% confidence interval 0.60–0.89), history of falls in the past year (3.65, 1.34–9.95), and Barthel index score (1.04, 1.00–1.08). This highlights the predictive value of better physical function but more difficult care status in relation to ADL for fall-related injuries.

Introduction

Previous studies that have examined falling among the elderly population have indicated dementia to be an important risk factor [1–3] and shown that falls by demented elderly people are associated with an increased rate of institutionalization [4]. However, only a few studies have focused on falls among elderly individuals with dementia [4–7] and little is known about them. A number of methodological problems related to the characteristic features of demented elderly people might have prevented researchers from attempting this kind of study. The most important problem appears to be difficulty in the appraisal of clinical status including activities of daily living (ADL), neurological, visual and auditory aspects as well as the reliability of reporting falls. It is now stressed that dementia is characterized by behavioural problems such as resistance to care or wandering [8, 9], which might predispose frail elderly individuals to falling. Thus, for the demented population, an observed behaviour-oriented fall study might yield practically useful information.

We conducted a one-year prospective study of falls among community-dwelling elderly individuals with dementia living in Yamanashi prefecture, Japan, paying particular attention to behavioural aspects.

Methods

Originally, three different groups of subjects were recruited: outpatients of our clinic, voluntary patients and their care-givers who were members of a self-help network for family nursing of demented individuals, and patients identified by formal service providers. From these, we selected study participants who met the following eligibility criteria: at least 55 years of age; independently mobile; living in a private residence; suffering from dementia based on the DSM-III-R [10] criteria; living with care-givers who were able to note and report any falls the participant sustained. We enrolled 112 patients meeting these criteria in a longitudinal study: 41 outpatients, 24 voluntary patients, and 47 patients identified by formal service providers.

As control subjects, 100 of 103 healthy volunteers recruited from the urban district of Kofu in Yamanashi prefecture participated. The eligibility criteria and examination procedure for the control subjects have been described in detail elsewhere [11]. Briefly, they were at lest 55 years of age, independently mobile, living in a private residence, and not suffering from dementia or depression.

Upon entry into the study, the first author visited each subject and made a baseline examination consisting of an interview, cognitive examination, manual neurological examination including Hachinski's ischaemic score [12], assessment of behavioural problems, and examination of ADL-related aspects. The interview elicited demographic data, information about medications currently being used, and history of

Table I. Estimated loading of 14 questionnaire items of the Troublesome Behaviour Scale for community-dwelling elderly with dementia

	Factor 1 Behaviour toward Caregivers	Factor 2 Self-absorbed behaviour	Factor 3 Elaborate behaviour
False accusation	0.67**		
Ill-natured denial and/or distortion	0.76**		
Hiding and/or losing things	0.28**	0.33**	
Interfering with a happy home circle	0.53**		
Being restless and/or noisy at night	0.54**		−0.37
Physical and/or verbal abuse	0.43**		
Repetition and/or clinging	0.38*		
Wandering		0.53**	
Pica (eating non-food items)	−0.47**	0.61**	
Rummaging (e.g. emptying drawers or closets)		0.52**	0.20
Making the dwelling dirty		0.34**	−0.39**
Crying and/or screaming		0.46**	−0.63**
Dangerous behaviour (e.g. driving, playing with fire)			0.52**
Quarrelling with others			0.35**

** $p < 0.01$, * $p < 0.05$.
The loadings are expressed as standardized causal coefficients.

falls in the past year. Cognitive function was evaluated using Hasegawa's dementia scale (HDS) [13].

Behavioural problems were assessed using the Troublesome Behaviour Scale (TBS), which had been developed by us [14]. The scale consists of questions assessing the observed frequency of 14 kinds of abnormal behaviour shown by demented patients in the preceding month (from 0 = never, to 4 = once every day or more). The mean value of Cohen's κ of all the items for test–retest and inter-rater were 0.72 (range 0.49–0.91) and 0.66 (0.48–0.88), respectively. To examine the construct validity of the scale, we employed confirmatory factor analysis to estimate values of the latent variables which are sums of direct and indirect contribution of the observed variables. The analysis revealed three structural latent variables, namely, 'behaviour toward care-givers', 'self-absorbed behaviour' and 'elaborate behaviour'. The final model of behavioural problems with estimated factor loadings (standardized causal coefficients) is shown in Table I. Scoring for the three factors was done on the basis of the estimated factor loadings.

To examine visual and hearing acuity, we first tried Snellen's type test and an ordinary audiometry, respectively. However, several of the patients could not follow the examination procedure, so these functions were estimated by dichotomous responses (preserved and abolished) based on evaluation by the care-giver responsible. We studied the reliability of the care-giver's evaluation by calculating a measure of agreement, κ, from 52 randomly selected pairs of primary care-giver and other family members. The values were 0.95 for visual function and 0.89 for hearing.

So-called apraxia/agnosia and impairment of motivation required for ADL are common symptoms of dementia and demented elderly people seem to have difficulty in caring for themselves because of these features [15]. These features also make it difficult to obtain a quantitative measurement of their ADL status using conventional scales. We therefore paid attention to care status related to assistance with basic ADL and developed a new scale named the Assessment of Basic Care for the Demented (ABCD) [16] (see Appendix). This consists of two sub-scales assessing the level of help difficulty (difficulty scale) and the reasons why assistance is needed (reason category) with regard to six types of ADL including ability to move to the right place when necessary (not merely ambulation). In the difficulty scale, each item is rated with four possible responses corresponding to the degree of physical assistance from the care-giver and of the patient's co-operation with the assistance (0 = requiring total help but resistant, 1 = requiring total help and not resistant, 2 = requiring occasional and/or partial help, 3 = requiring no help). For example, if a patient who is fully mobile but always wanders needs help to move to the right place when necessary, he/she is rated 0, 1 or 2 for the item. If a care-giver rates 0, 1 or 2 for each of five activities except voiding, a reason for the assistance will be chosen from reason category.

For the difficulty scale, Cronbach α was 0.93. The test–retest and inter-rater reliabilities have been confirmed. Predictive validity based on the assumption that patients with lower score would be more likely to be institutionalized and/or die within 1 year after the assessment has been confirmed. For the reason category, the reliabilities and the validity have been confirmed. A report is available from the authors that provides a more detailed analytic description of the TBS and the ABCD.

Besides care status evaluation using the ABCD, we measured ADL using the Barthel index [17] based on potential physical ability regardless of the effectiveness of the activities. For instance, if patients were able to dress themselves even though inappropriately, we judged that they had an ability to dress independently.

Using the results of baseline examination and additional data (brain CT and/or MRI, EEG, biochemical data), we made a diagnosis of probable or possible Alzheimer's disease or other dementia illnesses based on NINCDS–ADRDA [18]. The control subjects underwent a similar baseline examination, as described elsewhere [11].

In order to maximize the reliability of reporting falls [19], the outcome for the study subjects was restricted to fall-related injury which required medical attention and was

witnessed by others. For the control subjects, the outcome was self-reported fall-related injury which required medical attention. Furthermore, we gave a diary for recording fall-related injuries to each care-giver of the study subjects and control subjects at the baseline. The information about fall-related injuries sustained by the subjects was obtained through bimonthly telephone check-ups. For the control subjects, we held bimonthly check-up meetings and obtained the information. If a check-up was missed, we visited the subject as soon as possible to obtain the information.

To examine the association of dementia with fall-related injuries, logistic regression analysis was performed. In the analysis, we used the following independent variables: presence of dementia, age, sex, living in an urban or suburban/rural district, Barthel index score, history of falls in the past year (Yes, No) and number of drugs taken (total, antipsychotics, hypnotics–anxiolytics, antidepressants, cerebral metabolic activators and cerebral vasodilators, cardiovascular drugs and NSAIDs). A final model was constructed by using a stepwise procedure in which the presence of dementia was forced into each step.

Next, we attempted to identify the factors contributing to fall-related injuries among the study subjects. Data obtained from the baseline examination, except the results of the reason category of the ABCD, were used as independent variables. Univariate logistic regression analysis was performed on each independent variable, and unadjusted odds ratios and their respective 95% confidence intervals (CIs) were reported. Then stepwise logistic regression analysis was performed to determine which variables were most strongly associated with fall-related injuries, and a final model was used as a predictive equation for fall-related injuries. The data were analysed

Table II. Baseline characteristics of study and control participants

Variables considered contributory to fall-related injuries	Study subjects (n = 86)	Control subjects (n = 98)
Age: mean (SD)	77.5 (8.1)	73.7 (7.3)
(range)	(63–95)	(55–91)
Male sex (%)	40	31
Urban living (%)	22	100
AD and SDAT (%)	74	0
Falls in the past year (%)	28	17
Visual function:		
% of blindness	18	
visual acuity		0.5 (0.3)
Hearing function (% of deafness)	32	2
HDS score (cognitive function)*	8.9 (6.3)	28.4 (4.3)
(range)	(0–21)	(22–32.5)
Barthel index (ADL)**	81.6 (21.8)	98.9 (3.6)
(range)	(25–100)	(89–100)
Behaviour problems (TBS score)***		
Behaviour toward care-givers	0.1 (0.8)	—
Self-absorbed behaviour	0.1 (0.8)	—
Elaborate behaviour	0.2 (0.8)	—
ABCD score (care status)†	12.4 (4.2)	—
(range)	(3–18)	
Total no. (SD) of drugs	3.0 (2.9)	2.5 (2.6)
(range)	(0–12)	(0–10)
No. (SD) of:		
Antipsychotics	0.1 (0.3)	0
(range)	(0–2)	
Hypnotics–anxiolytics	0.3 (0.6)	0.3 (0.5)
(range)	(0–2)	(0–2)
Antidepressants	0.0 (0.1)	0
(range)	(0–1)	
Cardiovascular drugs	0.4 (0.9)	0.6 (0.9)
(range)	(0–4)	(0–4)
Cerebral metabolic activators and cerebral vasodilators	0.8 (1.0)	0.0 (0.1)
(range)	(0–3)	(0–1)
NSAIDs	0.1 (0.4)	0.2 (0.4)
(range)	(0–3)	(0–2)
Membership of self-help network for family care-giver (%)	21	0
Formal services user (%)	44	0

* Hasegawa's Dementia Screening Scale: full mark: 32.5, ⩽21.5: dementia suspected. ** Score ranges from 0 (most severe impairment) to 100 (no impairment); *** Higher score indicates more severity; † Score ranges from 0 (most difficult to care for) to 18 (no help needed).

Table III. Unadjusted odds ratios for the variables considered contributory to fall-related injuries

Variables considered contributory to fall-related injuries	Unadjusted odds ratio	95% CI
Age	1.0	(1.0–1.1)
Male sex	1.2	(0.5–2.7)
Urban living	1.1	(0.4–3.5)
Diagnoses of AD and SDAT	1.3	(0.5–3.2)
Falls in the past year**	3.9	(1.5–9.9)
Blindness	1.2	(0.4–3.6)
Deafness	2.1	(0.9–5.0)
HDS score**	0.9	(0.9–1.0)
Barthel index	1.0	(1.0–1.0)
TBS score (behaviour problems)		
Behaviour toward care-givers	1.3	(0.8–2.1)
Self-absorbed behaviour	1.6	(0.9–2.7)
Elaborate behaviour	1.0	(0.6–1.8)
ABCD score (care status)*	0.9	(0.8–1.0)
Total no. of drugs	1.1	(0.9–1.2)
No. of		
Antipsychotics	2.0	(0.6–7.0)
Hypnotics–anxiolytics	1.3	(0.7–2.7)
Antidepressants	1.5	(0.1–25.0)
Cerebral metabolic activators and cerebral vasodilators	1.4	(0.9–2.2)
Cardiovascular drugs	0.9	(0.6–1.5)
NSAIDs	0.7	(0.2–2.3)
Membership of self-help network for family care-giver	2.5	(0.9–6.5)
Formal services user	1.1	(0.5–2.5)

Unadjusted odds ratio was calculated in 1-point increments for continuous variables. CI denotes confidence interval. The results were obtained from univariate logistic regression analysis.
** $p < 0.05$; * $p < 0.01$.

using the SAS computer package; p values less than 0.05 were defined as significant.

Results

At the end of follow-up of the original 112 subjects, 86 were still participating in the study, 13 had died, 12 had become institutionalized, and one had become unavailable. Of 100 control subjects, two had died and one had been transferred to a nursing home. A final total of 86 study subjects and 98 control subjects was thus available for analysis. Detailed information about the final study and control subjects is given in Table II.

During the study period, 35 of 86 study subjects (41%) experienced fall-related injuries. Five of these 35 sustained fractures including four to the femoral neck. Of the 98 control subjects, 27 fell once or more and 9 (11%) sustained fall-related injuries including two fractures during the observation year.

To evaluate the effect of dementia on fall-related injuries controlling for effects of other variables described in statistical analysis, the forward stepwise logistic regression analysis was fitted using all subjects (n = 184). The presence of dementia (adjusted odds ratio 6.4, 95% CI 2.9–13.2) and history of falls in the past year (6.4, 2.9–13.8) were significant risk factors in the final model. The estimates of variables considered contributory to fall-related injuries by means of the unadjusted odds ratio and 95% CI in the final study subjects are presented in Table III.

Forward logistic regression analysis for the final 86 subjects revealed three risk factors that significantly and independently predicted fall-related injuries: lower difficulty score in the ABCD (more difficult care status), a history of falls in the past year, and a higher Barthel score (better ADL) (Table IV). Logistic regression analysis of the results yielded a predictive equation using the forward stepwise selection method.

Table IV. Adjusted odds ratios, which estimate the independent contribution of each variable to the likelihood of fall-related injuries, for the variables left in the final model

Risk factor	Adjusted odds ratio	95% CI
ABCD score*	0.7	0.6–0.9
Falls in the past year	3.7	1.3–10.0
Barthel score*	1.0	1.0–1.1
Intercept	0.9	0.2–5.5

CI denotes confidence interval. Adjusted odds ratios were obtained by multiple logistic-regression analysis.
* Calculated in 1-point increments for each scale.

Table V. Association between difficulty scale score and reason category of the ABCD and Barthel score

	Parameter estimate	Standard error	p value
Difficulty scale score	6.62	0.33	<0.0001
No. of B-items in reason category	5.29	0.84	<0.0001
Intercept	−13.48	3.86	0.0007

R square 0.78, F value 220.6, df 2, $p < 0.0001$.
The result was obtained from multiple regression analysis.

The equation at the final step classified 69% of the study subjects correctly and predicted those who sustained fall-related injuries in the subject population with 83% sensitivity and 48% specificity.

Although the difficulty scale was designed to measure aspects related to ADL, a lower difficulty scale score but a higher Barthel index score were contributory to fall-related injuries. To examine how the difficulty scale and reason category of the ABCD were associated with the Barthel index, we employed multiple regression analysis. In the analysis, we used the Barthel score as a dependent variable, and the difficulty scale score and number of A, B, and C items chosen in the reason category as independent variables. The analysis revealed that the difficulty scale score and number of B items contributed to the Barthel score (Table V).

Discussion

Thirty per cent of our control subjects reported falls during a one-year period, which was similar to the results of two of the largest community-based fall studies in generally healthy elderly subjects [1, 2]. Also it was revealed that the rate of those who sustained fall-related injuries was 6.4 times higher in the study subjects than in the control subjects. Buchner and Larson [5] reported that the fracture rate in patients with Alzheimer-type dementia (69/1000/year) was more than three times the age- and sex-adjusted fracture rate in the general population. Morris *et al.* [4] also reported that the occurrence of serious falls was three times higher in participants with senile dementia of the Alzheimer type (SDAT) than in healthy elderly people. The outcome examined in the present study was fall-related injury requiring medical attention, which included soft-tissue injuries and other minor injuries. When confined to fractures, our results seem to be similar to these previous findings.

The study highlights the predictive value of a lower difficulty scale score (more difficult care status related to assistance with basic ADL) and a higher Barthel score (better physical function) for outcome. To discuss the validity of our findings, it is necessary to bear the following points in mind. First, our outcome was not merely falls, but fall-related injuries. Second, using the difficulty scale of the ABCD, we measured difficulty in helping with ADL based on the degree of physical assistance from the care-giver and of the patient's co-operation with the assistance. On the other hand, using the Barthel index, we measured ADL based on potential physical ability regardless of effectiveness of activities.

With respect to the first point, many of the previous studies that examined falling in the general elderly population pointed out a worse ADL as a risk factor [1, 6, 19]. However, Speechley and Tinetti [20] reported that frail elderly people are more likely to fall but less likely to sustain related injuries than vigorous elderly subjects, arguing that the latter are more likely to engage in potentially dangerous activities and suffer a heavier fall impact. Our subjects comprise rather frail individuals with a Barthel score of 82 ± 22. On the other hand, Buchner and Larson [5] reported that wandering was significantly related to fractures sustained by patients with Alzheimer-type dementia. Of course, only those who are fully mobile can wander. Similarly, Brody *et al.* [6] pointed out the rating of physical vigour as a predictor of falls among institutionalized women with Alzheimer's disease. For these reasons, the contribution of better ADL to fall-related injuries seems to be valid.

Regarding the second point, we designed the difficulty scale of the ABCD to obtain a grasp of apraxia/agnosia and/or motivational loss summarized in section B of the reason category. As shown in Table V, when the score of the difficulty scale is controlled, the Barthel score increases as more B items are gained. This means that a demented elderly subject who has well preserved physical ability but shows these symptoms is likely to be rated better in terms of the Barthel index but worse in the difficulty scale. In other words, those symptoms seem to be associated with resistance to care as well as the requirement for more physical assistance. Therefore, we believe that the discrepancy in the contribution between the difficulty scale and Barthel index to the outcome is valid, and that this result does have clinical utility.

The so-called restraint and limitation style of fall-risk management amongst demented elderly patients, which has been stressed to be counter-productive, still persists [21]. This is attributable to some extent to the scantiness of practical information for predicting individuals at risk. Recently, various devices decreasing injury due to falls have been developed [22, 23], and their utility and safety have been reported [23, 24]. The present findings may be helpful for deciding which demented elderly patients should be assigned such devices.

Finally, we were unable to obtain accurate quantitative measurements of the visual and hearing functions of the study subjects. Further efforts to obtain more precise information on their physiological functions and biomechanics should yield fruitful results leading to the prevention of fall-related injuries among demented elderly people.

Appendix. Assessment of Basic Care for the Demented (ABCD)

The aim of this scale is to measure care status related to assistance with basic ADL for demented patients. This instrument is designed to be completed by family or professional care-givers. It consists of two subscales assessing the level of difficulty in helping with the ADL (difficulty scale) and the reasons why assistance is needed (reason category).

First, on the basis of your experience during the last one month, please indicate the difficulty scale by circling the appropriate number for each item, using this key:

Score 3: no help needed
2: occasional and/or partial help
1: total help and not resistant
0: total help but resistant

If you choose 0, 1 or 2 for each of five activities except voiding, please choose a reason for the assistance from the reason category.

Difficulty scale					Reason category
Ability to move to the right place when necessary					
	3	2	1	0	A: physical disability B: loss of motivation to move, goes the wrong way C: A and B
Dressing					
	3	2	1	0	A: physical disability B: loss of motivation to dress and/or undress, dresses inappropriately C: A and B
Bathing					
	3	2	1	0	A: physical disability B: loss of motivation to bathe, fails to use bathing tools C: A and B
Eating					
	3	2	1	0	A: physical disability, difficulty in chewing and/or swallowing B: refuses to eat, overeats, plays with food C: A and B
Personal hygiene					
	3	2	1	0	A: physical disability B: loss of motivation, fails to use tools C: A and B
Voiding					
	3	2	1	0	

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