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Original Article

An analysis of falls occurring in a convalescence rehabilitation ward — a decision tree classification of fall cases for the management of basic movements —

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ABSTRACT

Teranishi T, Kondo I, Tanino G, Miyasaka H, Sakurai H, Kaga J, Suzuki Y, Matsushima A, Kawakita M, Sonoda S. An analysis of falls occurring in a convalescence rehabilitation ward — a decision tree classification of fall cases for the management of basic movements —. Jpn J Compr Rehabil Sci 2013; 4: 7-13.

Purpose: A simple and discriminative method for evaluating the ability to maintain balance, the Standing test for Imbalance and DisEquilibrium (SIDE), was developed for fall risk management. As a preliminary step toward clinical application of the SIDE, this study aimed to determine a method of assessing the expected fall risk by analyzing fall cases using a decision tree classification for the management of basic movements.

Subjects and method: The subjects of this study were 513 patients who had been discharged from a convalescence rehabilitation ward over a one-year period (from January 1, 2010 to December 31, 2010). In cases when a fall occurred, we investigated the period from hospitalization and the classification of the patient, which was made with a decision tree describing the permitted activities of the patient and the management of the activities. The frequency of fall occurrence was determined by considering the number of patients who fell during every 15-day period during hospitalization.

Results: One hundred twenty patients fell during hospitalization. In total, 163 falls occurred. The incidence of falls was 4.65‰. Thirty patients suffered multiple falls. The falls occurred significantly more frequently during the first 15 days after admission. From classification by the decision tree, 62 falls occurred while the patients were being managed using physical restraints and/or sensors, 55 falls occurred during unpredictable actions of patients when the patients were not using physical restraints or sensors, and 26 falls occurred during permitted activities of patients.

Conclusion: Simple assessments of balance and adherence are necessary to reduce the occurrence of patient falls during the early period after admission.

Key words: convalescence rehabilitation ward, fall, classification, decision tree

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Introduction

A large number of incidents that happen in hospitals are falls [1, 2]. In Japan, the Japanese Nursing Association, Kaifukuki Rehabilitation Ward Association, and other organizations have proposed a number of fall risk assessments. Globally too, many fall risk assessments have been developed and applied in the clinical setting (e.g. Stratify, Morse fall scale, and Hendrich II Fall Risk Model).

However, many of these fall risk assessments consist of fall-related factors (e.g. history of falls, motor paralysis, sensory disturbance, cognitive disturbance, balance deficiency, medicines that influence balance ability, and locomotion strategy), and the fall risk of a patient is judged by the weighted sum of the scores for those fall-related factors [3−7]. More specifically, the patients were divided into two groups based on a cutoff value, a high-risk group and a low-risk group. Moreover, mobilizing extensive human and material resources has been recommended for patients in the high-risk group [7].

The total score of a fall risk assessment, however, is the sum of various directional factors (e.g. sensory disturbance, cognitive defect, and balance disorder). Thus, two identical scores have different meanings, and designing a management method for each patient with fall risks is cumbersome. To the best of our knowledge, there have been no studies on improving these management methods.

In general, fall risk factors are divided into two categories, internal factors and external factors. However, a fall occurs when a patient's postural sway is beyond the patient's ability to maintain balance even in a controlled environment such as a convalescence rehabilitation ward.

There are, however, remarkably few items for evaluating the ability to maintain balance in current fall risk assessments. Accordingly, we developed the Standing test for Imbalance and DisEquilibrium (SIDE), which is a simple discriminative evaluation of balance. We have previously determined the reliability and validity of the SIDE [8, 9].

The purpose of this preliminary study was to determine the falls that occurred in a convalescence rehabilitation ward. The falls were analyzed and organized retrospectively by methods for managing basic movements to determine what kind of fall risk assessment is required in order to manage basic movements.

This study was approved by the ethics committee of Fujita Health University, Nanakuri Sanatorium (Nanakuri Ethics Committee No. 88).

Subjects and method

The subjects of this study were 513 patients discharged from the 106-bed convalescence rehabilitation ward in Fujita Health University, Nanakuri Sanatorium over a one-year period (from January 1, 2010 to December 31, 2010).

Table 1 shows the backgrounds of the subjects. Nanakuri Sanatorium provides medical rehabilitation services 365 days a year.

Furthermore, to better understand the subjects and their respective circumstances, we investigated the total number of patients (the total number of patients discharged from the convalescence rehabilitation ward between January 1, 2010 and December 31, 2010), the total number of days of hospitalization (the total number of hospitalization days of all patients), and the daily distribution of the medical staff.

The occurrence of falls, information regarding age, sex, medical diagnosis, functional independence measure (FIM) motor score, FIM cognitive score, and scores from the functional assessment of daily living table at admission were determined from medical charts or incident reports. In cases in which falls occurred, we investigated the period from the start of

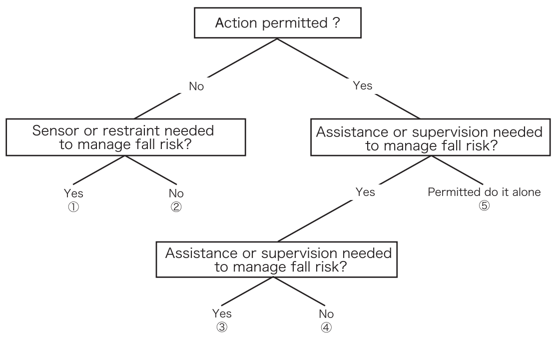

Figure 1. Decision tree classification by the method for managing basic movements.

Table 1. The backgrounds of the 513 patients included in the study.

Diagnosis	stroke 378 (infarction 202, hemorrhage 153, subarachnoid hemorrhage 23), spinal cord disorder 34, femoral neck fracture 23, disuse syndrome 15, others 63
Sex and age at the time of admission	Male 293 patients (65.8 ± 15.1 years old), Female 220 patients (71.9 ± 13.9 years old)
FIM total score of motor items	48.3 ± 24.1
FIM total score of cognitive items	23.3 ± 9.8
Functional assessment of daily living table scores	6.84 ± 4.88

hospitalization, the place where the fall occurred, the level of incident and the class of patient which was made with a decision tree (Figure 1) according to the management of basic movements. The rate of occurrence was calculated according to the following equation "rate of occurrence = (number of fall incidences/man-days of hospitalization)/1000".

The procedure of classification with a decision tree (Figure 1) was as follows. First, we determined whether the activity that preceded the fall was permitted. Next, if falls occurred during a prohibited activity, those that occurred under sensor monitoring or restraint were classified as No. 1, and those that occurred because of a patient's unexpected actions were classified as No. 2. Alternatively, if falls occurred during a permitted activity, we divided the activity according to whether supervision by a medical staff was required. Falls that occurred while patients were under supervision or receiving assistance were classified as No. 3, and those that occurred while the patients required supervision or assistance but the staff failed to supervise or assist were classified as No. 4. Falls that occurred while the patients performed activities that they were permitted to do alone, without supervision, were classified as No. 5.

The criteria for sensor monitoring or restraint and the scope of permission for activities were decided subjectively by mutual consent of medical team members of our hospital.

Herein, a "fall" is defined as occurring when any part of the body except the soles of a patient's feet involuntarily contacted the floor.

The frequency of fall occurrence was calculated by considering the number of patients who fell during every 15-day period during hospitalization. Haberman's residual analysis method (PASW Statistics ver. 18, IBM Co.) was used to determine the significant time interval.

Results

Over a one-year period, 513 patients were discharged. There were 163 cases of falls by 120 patients. The total length of hospitalization for all patients was 35,067 days. Thirty patients experienced multiple falls (four times: 2 patients, three times: 9 patients, twice: 19 patients). The incidence rate of falls was 4.65‰, as shown in Figure 2. The distribution of medical staff each time was approximately 10 persons less during the daytime on Saturdays, Sundays and national holidays (Table 2).

Tables 3a and 3b show the time after admission for fall incidents. The number of falls during each 15-day period gradually decreased as hospitalization progressed; the number was significantly high ($p<0.05$) during the first 15 days of a patient's admittance to the hospital. We also divided the first 15 days after admission into 3-day increments and analyzed the number of falls. As a result, the occurrence of falls during the first 3 days of the patient's admittance to the hospital is significantly high ($p<0.05$).

Figure 1 shows the results of classifying the falls using the decision tree: 62 cases of No. 1 occurred while patients were under sensor monitoring or restraint, 55 cases of No. 2 occurred during patients' unexpected actions, 11 cases of No. 3 occurred while patients were under supervision or receiving assistance, 9 cases of No. 4 occurred while the patients needed

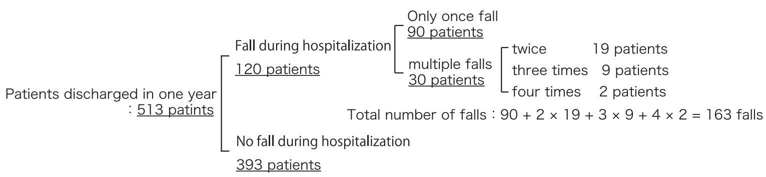

Figure 2. Breakdown of subject falls.

Table 2. The daily distribution of medical staff of day schedule (sum of nurses, care staffs and nursing assistants, not includIng physicians and therapists).

Time	7:30 – 8:45	8:45 – 9:00	9:00 – 12:30	12:30 – 15:30	15:30 – 17:00	17:00 – 19:00	20:45 – 21:00	21:00 – 7:30
Weekday (Monday to Friday) distribution of personnel (persons)	8	33	30	29	22	8	14	6
Saturdays, Sundays and national holidays include distribution of personnel (persons)	8	24	19	16	16	8	12	6

supervision or assistance but the staff failed to supervise or assist, and 26 cases of No. 5 occurred while the patients were doing permitted activities alone.

The relationship between a classification of the decision tree and the time of occurrence after admission is shown in Table 4. Many of the No. 1 and No. 2 classifications occurred from 1 to 15 days after admission. Twenty-three cases classified as No. 1 during this period equal 37% of the total number of No. 1 falls during the entire period of hospitalization. Thirty-two cases classified as No. 2 during 1 to 15 days after admission equal 58% of the total number of No. 2 falls during the entire period of hospitalization. Many of the falls classified as No. 5 occurred from 31 to 45 days after admission. Nine cases classified as No. 5 during this period equal 35% of the total number of No. 5 falls during the entire period of hospitalization.

The relationship between decision tree classification and place of occurrence is shown in Table 5. The majority of falls (123 cases) occurred in patients' rooms; the rest of the falls occurred "in a rest room (17 cases)" or "in a corridor (14 cases)". Regarding falls in patients' rooms, 51 cases (41%) were classified as No. 1, 42 cases (34%) were classified as No. 2, and 18 cases (15%) were classified as No. 5. Regarding falls mainly in a rest room, nine cases (53%) were classified as No. 2. Regarding falls in a corridor, six cases (43%) were classified as No. 2.

The relationship between a classification of the decision tree and the time of occurrence after admission is shown in Table 6. The following describes the occurrence of falls in descending order. Thirty-nine cases (24%) occurred between 6:00 and 9:00, 36 cases (22%) between 18:00 and 21:00, and 26 cases (16%) between 12:00 and 15:00. Of falls classified as No. 1, 18 cases (29%) occurred between 18:00 and 21:00,

Table 3a. Total number of admitted patients and the days until fall.

Outbreak period of fall (days)	1−15	16−30	31−45	46−60	61−75	76−90	91−105	106−120	121−
Total number of patients (cases)	7,581	6,845	5,755	4,662	3,566	2,480	1,544	994	1,640
Number of patients who fell (cases)	62	28	23	16	14	10	10	1	3

Table 3b. Total number of admitted patients and the days until fall.

Outbreak period of fall (days)	1−3	4−6	7−9	10−12	13−15
Total number of patients (cases)	1,537	15,332	1,521	1,505	1,486
Number of patients who fell (cases)	29	16	6	8	3

Table 4. Relationship between classification of the decision tree and the time of occurrence after admission.

	Classification of decision tree					
Days from admission (days)	①	②	③	④	⑤	Total (cases)
1−15	23	32	1	3	3	62
16−30	9	10	2	1	6	28
31−45	6	5	1	2	9	23
46−60	8	4	1	1	2	16
61−75	8	3	2	0	1	14
76−90	4	0	1	1	4	10
91−105	2	1	2	0	1	6
105−	2	0	1	1	0	4
Total (cases)	62	55	11	9	26	163

Table 5. Relationship between decision tree classification and occurrence place.

	Classification of decision tree					
Site of occurrence	①	②	③	④	⑤	Total (cases)
Patient's room	51	42	8	4	18	123
Lavatory	3	9	0	3	2	17
Corridor	6	1	3	1	3	14
Dining room	0	3	0	0	1	4
Bathroom	1	0	0	1	2	4
Nurse station	1	0	0	0	0	1
Total (cases)	62	55	11	9	26	163

Table 6. Relationship between classification of the decision tree and the time of occurrence after admission.

	Classification of decision tree					
Time of occurrence	①	②	③	④	⑤	Total (cases)
0:00–3:00	5	2	1	0	0	8
3:00–6:00	7	4	1	1	4	17
6:00–9:00	13	16	0	3	7	39
9:00–12:00	5	2	2	0	3	12
12:00–15:00	6	14	2	2	2	26
15:00–18:00	5	6	2	0	3	16
18:00–21:00	18	8	3	2	5	36
21:00–0:00	3	3	0	1	2	9
Total (cases)	62	55	11	9	26	163

Table 7. Number of falls per day of the week.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total (cases)
Number of falls (cases)	20	22	23	24	27	26	21	163

Table 8. Total number of falls at each incident level.

Incident level*	level 0	level 1	level 2	level 3a	level 3b	level 4	level 5
Total number of falls (cases)	13	18	126	5	1	0	0

* Incident level
- level 0 Incident did not affect the patient
- level 1 Incident might have affected the patient but did not do actual harm to the patient
- level 2 Incident increased observation or incurred extra examination
- level 3a Incident triggered a minor medical procedure or medical treatment
- level 3b Incident triggered a major medical procedure or medical treatment
- level 4 Incident triggered a permanent disability
- level 5 Incident became the cause of patient's death

and 13 cases (21%) occurred between 6:00 and 9:00. Of falls classified as No. 2, 16 cases (29%) occurred between 6:00 and 9:00, and 14 cases (25%) occurred between 12:00 and 15:00. Seven cases (27%) classified as No. 5 occurred between 6:00 and 9:00. Many falls occurred during the breakfast, lunch and dinner hours. The incidence of falls tended to be higher on Fridays and Saturdays (Table 7).

In addition, there were 13 cases of level 0 incident, 18 cases of level 1 incident, 126 cases of level 2 incident, 5 cases of level 3a incident and 1 case of level 3b incident (Table 8).

Discussion

Suzuki et al. reported that 273 falls occurred for 121 patients among 256 patients admitted to an 88-bed rehabilitation ward of a hospital. Compared to the total number of admitted patients (256) in this ward, the rate of falls was 106.6% and the rate of patients that experienced falls was 42.7% [11]. A multicenter study was done when the Kaifukuki Rehabilitation Ward Association developed the fall risk assessment sheet. In that study, 373 (33.8%) of 1,107 stroke inpatients had fallen during hospitalization, with a total of 1,370 (123.8%) falls [7].

In our study, 120 (23.4%) of 513 inpatients had fallen and 163 falls occurred during the hospitalization period. This result suggested that we maintained good control of the fall occurrence rate. Furthermore, as an index of multiple falls, the ratio of falls to the number of patients who fell was 2.26 (273/121) for the first study and 3.67 (1370/373) for the second study. On the other hand, the rate of falls was 1.36 (1163/120). This suggested that the occurrence rate of multiple falls would be smaller than in the other study [7, 11].

However, these results were obtained by excessive behavioral suppression. Therefore, a more detailed study of activity management methods for hospitalized patients is necessary.

This survey showed that 5 of 163 falls were level 3a incidents, one was a level 3b incident and the other falls were level 2 incidents. There were very few serious cases, and there was only one accident with bone fracture. We think that anticipating and preventing falls is very important. The fear of falling limits the patients' activities of daily living, increases the amount of care required, and constricts early independence during patients' daily living.

Previous studies reported that many falls occurred during the early period after a patient's admission. However, many of those studies did not consider statistically the loss of patients by discharge over time. In the present study, we considered this loss and our results still showed that a significantly larger number of falls occurred within 15 days after admission. We also found that within these 15 days after admission, the fall occurrence is significantly more frequent within the first 3 days.

The overwhelming majority of falls occurred in the patients' rooms and many falls occurred at meal times. These results were the same as the findings of previous studies. The time soon after a patient's admission is the period when evaluations are performed by various staff, when the members of a medical team are not able to fully and accurately understand the patient's abilities.

This is likely the reason why many falls occur within 3 days after admission. During this initial period, a different methodology of fall risk assessment from that used during the latter period is necessary for the management of fall risk. Therefore, a valid and simple assessment for fall risk management that is easily applicable on the day of admission should be developed.

There are three important points when considering the prevention of patients' falls. The first is the metacognitive ability regarding a patient's own ability to maintain balance. The second is the permission level of activities of daily living based on the patient's ability to maintain balance (balance evaluation). The third is the ability of a patient to keep their promise (adherence evaluation).

Furthermore, a convalescence rehabilitation ward is a place where patients are encouraged to expand their living area according to their capacity that can be achieved by everyday exercise. Thus, patients do not have sufficient metacognitive ability regarding self balance at a rehabilitation ward just after their admission. An evaluation of the extent of permitted action, which is decided by their balance ability and the ability of the patient to maintain this extent of permitted action, is important.

Table 9 shows the improvement method for each of the decision tree classifications by methods for managing basic movements. Class No. 1 falls are those that occur while using a sensor or restraint. Accordingly, we should devise better sensor systems or restraint methods. Class No. 2 falls are those that occur unexpectedly by patients' actions without using a sensor or restraint. Accordingly, we should decide apposite criteria for use of a sensor or restraint by an adherence evaluation. Class No. 3 falls are those occur while a caregiver is with a patient. Accordingly, we should educate care staff about assistance techniques. Additionally, we must decide the appropriate fall risk management method for these patients using a combined evaluation of balance and adherence. Class No. 4 falls are those that occur while a caregiver leaves a patient alone unsupervised. Accordingly, we should consider the distribution of the staff working on the ward and if there are two separate patients who require supervision by a caregiver, a caregiver should supervise the higher-priority patient. In conclusion, we should develop an adherence evaluation for determining higher-priority patients. Class No. 5 falls

Table 9. Improvement method for each of the decision tree classifications by methods for managing basic movements.

Class of decision tree	①	②	③	④	⑤
Typical fall incidents	Patient slipped through a sensor system or restraint	Fall occurred due to unexpected action by patient without using a sensor or restraint	Fall occurred while a caregiver was with a patient	Fall occurred while a caregiver had left a patient unsupervised alone	Fall occurred while a patient was doing a permitted activity alone
Methodology for reducing fall incidents	Devising better sensor system or restraint method	Deciding apposite criteria for use of sensor or restraint by an apposite adherence evaluation	Educating care staff on assistance techniques, deciding appropriate fall risk management method for these patients using a combination of apposite balance and apposite adherence evaluation	Adding staff, supervising higher-priority patients, deciding a management method by an apposite adherence evaluation	Permitting activities by an apposite balance evaluation

are those that occur while a patient is doing a permitted activity alone. Accordingly, we should permit activities by apposite balance evaluation for the prevention of Class No. 5 falls.

The impairment and disability of patients improve daily in a convalescence rehabilitation ward, and so the areas of their activities will expand. As discussed previously, the applicable areas of activities of the patient need to be determined based on balance ability and adherence level. Deciding applicable areas of activities of the patient will decrease the frequency of fall occurrences and improve the disabilities.

It is especially important to develop a new simple fall risk assessment that includes the factors of adherence and the ability to maintain balance. We think that if a new simple fall risk evaluation with balance and adherence factors is developed, the significantly higher fall risk of patients during the early period after admission will decrease.

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