Journal of the Neurological Sciences 356 (2015) 113–117

Contents lists available at ScienceDirect

Journal of the Neurological Sciences

journal homepage: www.elsevier.com/locate/jns

A prediction model of falls for patients with neurological disorder in acute care hospital

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ARTICLE INFO

Article history:
Received 24 December 2014
Received in revised form 27 May 2015
Accepted 14 June 2015
Available online 16 June 2015

Keywords:
Fall
Gait
Neurological disorder
Prediction model
Acute care
Fall risk assessment

ABSTRACT

For the prevention of falls, individual fall risk assessment is the necessary first step. Thus, we attempted to identify independent risk factors for falls and develop a prediction model using a scoring system for patients with neurological disorders in acute hospital settings. This study was a secondary analysis of a previous study performed to compare the reliability and validity of three well-known fall assessment tools in patients with neurological disorders. We considered comorbid diseases and potential medications in addition to variables included in the three tools. Multiple logistic regression analysis was used to develop a prediction model for falls. Predictive scores were calculated using the proportional odds ratio (OR) of each predictor. The discriminative power of this model was evaluated by receiver-operating characteristic (ROC) area under the curve (AUC) analysis. A total of 32 falls were noted among 1018 patients. History of falls (OR, 4.01; 95% CI, 1.61–9.98; $p = .003$), cerebrovascular disease (CVD) (OR, 2.61; 95% CI, 1.11–6.14; $p = .028$), severe impaired gait (OR, 7.28; 95% CI, 2.45–21.65; $p < .001$), and overestimate of one's own gait ability (OR, 9.14; 95% CI, 3.89–21.45; $p < .001$) were identified as meaningful predictors for falling after adjusting for age, diabetes, confusion or disorientation, up-and-go test, altered elimination, and antipsychotics by univariate analysis. The discriminative power of fall risk score calculated by the prediction model was 0.904 of AUC ($p < .001$). Our results suggest that in addition to fall history and the presence of CVD, neurological assessment for gait and insight into gait ability are imperative to predict falls in patients with neurological disorders.

1. Introduction

Falls are unexpected but nevertheless common accidents in hospitalized patients [1] as well as in older adults dwelling in communities [2]. In addition to prolonged hospital stays and high medical costs [2–4], falls can cause serious injuries such as osteoporotic fractures and head trauma, and in some cases death. Many risk factors for falls have been reported in the literature, including age, gait, balance deficits, depression, cognitive impairments, and medications [2,4,5]. In recent years, even subtle or mild cognitive impairments have been recognized as an independent risk factor for falling due to their influence on gait variability [6,7]. Therefore, even neurological patients with symptoms such as mild motor, sensory or cognitive deficit, as well as individuals who have had a stroke or are suffering from dementia are at a relatively high risk for falling [5,8,9].

Assessment of individual risk is an essential and important first step for preventing falls in various interventions, especially when using a validated tool such as the Morse fall scale (MFS) [10], the Hendrich II fall risk model (HFRM II) [11], and the St. Thomas's risk assessment tool in falling elderly inpatients (STRATIFY) [12]. However, these tools produce different predictive values of falls depending on clinical setting, namely, acute care setting or nursing home facilities [13] as well as among populations in the same settings [14,15]. Thus, these tools have relatively low sensitivities and prediction values even though they are the most commonly used tools in clinical practice [14–17]. In addition, there are essentially no useful screening tools or clinical parameters to assess fall risks for patients with neurological disorders who are at very high risk for falling in acute care settings [5].

We recently evaluated the MFS, HFRM II, and STRATIFY scales in patients with neurological disorders admitted in an acute care setting to determine which was the most validated and appropriate tool for this patient population. However, we found that all of these tools had either relatively low sensitivities of approximately 50 to 60% or low specificities of about 73% [18] for the prediction of falls. This suggests that currently used and well validated fall assessment tools for all hospitalized patients in Korean clinical practice, such as MFS [19–21],

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http://dx.doi.org/10.1016/j.jns.2015.06.027
0022-510X/

might not be sensitive in this population. Thus, there is a need to develop an improved screening or assessment tool validated in acute neurological patients in order to more effectively predict falls in this subset of patients.

Here, we sought to identify independent risk factors for falls in patients with neurological disorders admitted into an acute care hospital after adjusting for potential risk factors such as comorbid diseases and medications as well as variables described in several well-known tools. As a result, we propose a new prediction model using a simple scoring system that should allow clinicians and nurses to more quickly and effectively assess individual risk factors for falls.

2. Patients and methods

2.1. Study design and patients

This was a methodological study to develop a prediction model and examine its accuracy. This study was conducted as a secondary analysis of a previous study [18] that compared the reliability and validity of three fall assessment tools: the Morse fall scale (MFS), the Hendrich II fall risk model (HFRM II), and the St. Thomas risk assessment tool in falling elderly inpatients (STRATIFY). The previous study, on which the current work is based, was approved by the institutional review boards of the Asan Medical Center.

Patients were enrolled between July 1 and October 31, 2011 at the Asan Medical Center, Seoul, Korea. The inclusion criteria were as follows: (1) adults patients 20 years of age or older, (2) neurological disorder as the primary diagnosis, (3) admitted to the neurology, neurosurgery, or rehabilitation department for the first time during the study period due to acute problems such as development of CVD or severe aggravation of Parkinson's disease, and (4) consent by the patient or family. A total of 1026 consecutive patients were enrolled in this study and compared using the three tools described above. Data from 1018 patients were used after excluding inadequate data.

2.2. Clinical measurement

All data were collected by five well-trained nurses (one nurse per ward) using face-to face interviews with a structured questionnaire that covered general characteristics (age, gender, history of falling, and the presence of family or private caregiver), various neurological and physical conditions, comorbid diseases (hypertension, diabetes, cardiac disease, cancer, and so on), and potential medications (benzodiazepines, anti-psychotics, diuretics, and antidepressants). Various neurological and physical conditions used as variables in the three fall assessment tools included confusion or disorientation, mental status, depression, dizziness, gait, up-and-go test, altered elimination, and presence of intravenous therapy. In MFS, 'mental status' meant whether a patient had the exact judgment of one's own gait ability or overestimated that. Also, gait was defined as follows: 1) 'normal gait' for patients with no weakness or bed-rest state; 2) 'weak gait' for patients who could walk balanced and independently despite short steps; and 3) 'impaired gait' for patients who were unable to walk independently without assistance from another person, furniture, or walker. For exact understanding, we replaced 'mental status' to 'overestimate of one's own gait ability' with the reverse coding, and 'weak gait' and 'impaired gait' to 'mild impaired gait' and 'severe impaired gait', respectively.

Prior to our investigation we provided instructions for each fall assessment tool and its respective scale to each of the five nurses who administered questionnaires. In a previous study [18], the inter-rater reliability of each tool had kappa values of .819, .895, and .868 for MFS, HFRM II, and STRATIFY.

All interviews and neurological and physical assessments were performed within 48 h of admission. All falls that occurred in wards were reported to the unit manager and the investigator assigned to each ward. Patients who fell were re-assessed for their neurologic and physical conditions by the investigator.

2.3. Data analysis

General characteristics, neurological and physical conditions, comorbid diseases, and potential medications for patients who fell and those who did not fall were compared using the chi-square test, Fisher's exact test, and independent *t*-tests where appropriate. A stepwise multiple logistic regression analysis was used to determine independent predictors of falls. Variables were selected for entry into the logistic model based on the results of a univariate analyses ($p < 0.1$). The Hosmer–Lemeshow goodness-of-fit test was used to assess how well the model accounted for specific outcomes.

The prediction model for falls was developed from the results of the multivariate analysis. The predictive score was calculated by odds ratio-based scoring method [22], and the nearest integer scores were assigned to each predictor. Total fall scores were determined by summing the points assigned for each predictor. Model discriminative power was evaluated by receiver-operating characteristic (ROC) area under the curve (AUC) analysis. An optimal cutoff value for adequate sensitivity and specificity was also implemented based on Youden index [23]. To compare the performance of this fall risk score and other fall assessment tools evaluated in a previous study [18], sensitivity, specificity, predictive value, AUC and Youden index values were used.

All statistical analyses were performed using SPSS for Windows (version 21.0; IBM SPSS Statistics for Windows, Armonk, NY: IBM Corporation) [24]. Two tailed $p < 0.05$ was considered as statistically significant.

3. Results

3.1. Characteristics of subjects

A total of 1018 patients were included in this study. The mean (SD) age was 56.34 (18.87) years, and 482 (47.3%) patients were men. There were 469 (46.1%) patients with cerebrovascular disease (CVD), 182 (17.9%) with tumors, and 100 (9.8 %) with a neuro-degenerative disease such as Parkinson's disease or dementia. A total of 32 falls were documented during the study period, and there were no serious complications such as hemorrhage or fracture.

3.2. Predictors of falls in acute neurological patients

Age ($p = .009$), history of falling ($p < .001$), diagnosis ($p = .038$), confusion or disorientation ($p = .022$), overestimate of one's own gait ability ($p < .001$), mobility problem ($p < .001$), gait ($p < .001$), up-and-go test ($p < .001$), altered elimination ($p = .002$), and antipsychotics ($p = .029$) were significantly associated with falling according to univariate analysis (Table 1).

To investigate independent risk factors of falling, we inserted all of the above variables excluding mobility problem similar to gait function and diabetes ($p = .07$) into a multivariate model. In this approach, history of falling (OR, 4.01; 95% CI, 1.61–9.98; $p = .003$), CVD (OR, 2.61; 95% CI, 1.11–6.14; $p = .028$), severe impaired gait (OR, 7.28; 95% CI, 2.45–21.65; $p < .001$), and overestimation of one's own gait ability (OR, 9.14; 95% CI, 3.89–21.45; $p < .001$) were independently associated with the presence of falling in acute neurological patients (Table 2).

3.3. A prediction model of fall and predictive scores

To develop an improved prediction model we selected the 4 remaining variables in the stepwise multiple logistic regression and calculated an integer score proportional to their odds ratios on logistic regression (Table 2). The final fall risk score was calculated using the following