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Development and validation of a prediction model for functional decline in older medical inpatients

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ABSTRACT

Objective: To prevent functional decline in older inpatients, identification of high-risk patients is crucial. The aim of this study was to develop and validate a prediction model to assess the risk of functional decline in older medical inpatients.

Methods: In this retrospective cohort study, patients ≥65 years admitted acutely to medical wards were included. The healthcare database of 246 acute care hospitals (n = 229,913) was used for derivation, and two acute care hospitals (n = 1767 and 5443, respectively) were used for validation. Data were collected using a national administrative claims and discharge database. Functional decline was defined as a decline of the Katz score at discharge compared with on admission.

Results: About 6% of patients in the derivation cohort and 9% and 2% in each validation cohort developed functional decline. A model with 7 items, age, body mass index, living in a nursing home, ambulance use, need for assistance in walking, dementia, and bedsore, was developed. On internal validation, it demonstrated a c-statistic of 0.77 (95% confidence interval (CI) = 0.767–0.771) and good fit on the calibration plot. On external validation, the c-statistics were 0.79 (95% CI = 0.77–0.81) and 0.75 (95% CI = 0.73–0.77) for each cohort, respectively. Calibration plots showed good fit in one cohort and overestimation in the other one.

Conclusions: A prediction model for functional decline in older medical inpatients was derived and validated. It is expected that use of the model would lead to early identification of high-risk patients and introducing early intervention.

1. Introduction

In super-aged societies, preventing functional decline in older inpatients is an important issue. After acute admission, 20–30% of older patients experience a functional decline, (De Saint-Hubert et al., 2010) which is associated with nursing home placement, poor quality of life, increased costs of care, readmission, and mortality (Covinsky, Justice, Rosenthal, Palmer, & Landefeld, 1997; Fortinsky, Covinsky, Palmer, & Landefeld, 1999; Sager & Rudberg, 1998). While functional decline is not strictly related to the medical condition leading to admission, several factors, such as age, the physical and cognitive status of patients before admission, iatrogenic effects of treatment, effects of bed rest, and comorbidities, play a role (Miller & Weissert, 2000). Since appropriate management including comprehensive geriatric assessment can prevent functional decline, identification of high-risk patients and early intervention are crucial (Ferrucci, Guralnik, & Studenski, 2004).

Abbreviations: TRIPOD, transparent reporting of a multivariable prediction model for individual prognosis or diagnosis; MDV, medical data vision; DPC, diagnosis-procedure combination; ADL, activities of daily living; BMI, body mass index; AIC, akaike information criterion; ISAR-HP, identification of seniors at risk – hospitalized patients

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Although there have been several clinical prediction models for functional decline in older inpatients, (Cornette et al., 2006; Hoogerduijn et al., 2012; Huyse, de Jonge, & Slaets, 2001; Sager, Rudberg, & Jalaluddin, 1996; Wu, Yasui, & Alzola, 2000) they were not designed to specifically predict functional decline, (Huyse et al., 2001) or they did not show sufficient predictive performance (De Saint-Hubert et al., 2010; Cornette et al., 2006; Hoogerduijn et al., 2012; Huyse et al., 2001; Sager et al., 1996; Wu et al., 2000). Furthermore, the performance of these existing models has not been evaluated in an appropriate way as recommended by the guideline for transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD) (Moons, Altman, & Reitsma, 2015). For example, although calibration (agreement between predictions from the model and observed outcomes) is a key feature of prediction models and is recommended to be reported, it has not been reported in some previous studies (Huyse et al., 2001; Sager et al., 1996). In addition, these models have not been externally validated (Cornette et al., 2006; Wu et al., 2000) or they did not show sufficient performance in the external validation sets (Hoogerduijn et al., 2012; Huyse et al., 2001; Sager et al., 1996). Thus, existing prediction models have not been widely used.

Therefore, the aim of the current study was to develop and validate a new clinical prediction model following the standard guideline to assess the risk of functional decline in older medical patients admitted to acute care hospitals.

2. Materials and methods

This study was designed to develop and validate a prediction model for functional decline in older medical patients admitted to acute care hospitals. The TRIPOD guideline for prediction model studies was followed (Moons et al., 2015). Ethical approval was granted by the Ethics Committees of Kyoto University Graduate School and Faculty of Medicine (R0463), Shirakawa Kosei General Hospital (HAKURIN 15-021), and Tenri Hospital (765).

2.1. Study design and data source

For derivation of the model, the healthcare database provided by Medical Data Vision (MDV) Co., Ltd (Tokyo, Japan) was used. The database contains Japanese diagnosis-procedure combination (DPC) data, which is a national administrative claims and discharge database of acute care inpatients (Matsuda, Kuwabara, Fujimori, Fushimi, & Hashimoto, 2008). The DPC data include patient demographics and selected clinical information, admission and discharge statuses, diagnoses, and special reimbursements for specific conditions. It was derived from hospitals located throughout Japan and anonymously managed to protect patients' personal information. The source population of the database was derived from 246 acute care hospitals with a mean of 357 beds, which was about 15% of acute care hospitals with the DPC system in Japan. The data between April 1, 2014 and September 30, 2015 were retrospectively analyzed. For external validation of the model, DPC data of Shirakawa Kosei General Hospital (a teaching hospital with 471 beds in Fukushima, northeastern region of Japan) and Tenri Hospital (a teaching hospital with 1001 beds in Nara, western region of Japan) between April 1, 2014 and September 30, 2015 were used.

2.2. Patients

From each dataset, patients who were 65 years old or older admitted to medical wards including departments of cardiology, respirology, gastroenterology, hematology, metabolism, endocrinology, nephrology, neurology, allergy, rheumatology, geriatrics, and general medicine were included. Exclusion criteria were: 1) patients unable to experience functional decline (patients with a Katz activities of daily living (ADL) score of 0 (totally dependent) at admission and patients who died during admission); 2) patients transferred from another ward of the hospital or another hospital; and 3) the purpose of admission was checkup, education, or planned short stay (e.g. for scheduled radiation/chemotherapy).

2.3. Data collection

From the DPC database, the following items were collected: age, sex, height, weight, date of admission and discharge, admission route, ambulance use, Katz ADL scores on admission and at discharge, (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963) independence in daily living for the demented elderly on admission, cancer status, consciousness disturbance on admission and discharge, bedsore status, International Classification of Diseases, Tenth Revision, length of hospital stay, and in-hospital mortality. Based on clinical experience and a review of the existing literature, (De Saint-Hubert et al., 2010; Hoogerduijn, Schuurmans, Duijnstee, de Rooij, & Grypdonck, 2007; Warnier et al., 2016) an a priori list of predictors for functional decline was identified, including the following items: age, body mass index (BMI), living in a nursing home (living in a nursing home = 1, not living in a nursing home = 0), ambulance use (ambulance use = 1, no use = 0), need for assistance in walking (need for assistance in walking = 1, no need = 0), independence in daily living for the demented elderly on admission (with dementia = 1, no dementia = 0), bedsore (with bedsore = 1, no bedsore = 0). Assessment of independence in daily living for the demented elderly on admission is necessary to apply for long-term insurance in Japan, and it is known to correlate closely with the Mini-Mental State Examination (Hisano, 2009). It classifies older people into 6 categories: no dementia = 0; has some type of dementia, but almost independent = I; some daily life-disturbing symptoms, but can lead daily life independently if watched by someone = II; daily life-disturbing symptoms that require assistance = III; daily life-disturbing symptoms that require frequent assistance = IV; and marked psychiatric symptoms requiring expert management = M. It was used as an index for whether patients had dementia or not: 0 on the scale was defined as a patient without dementia (=0), while I–IV and M were defined as a patient with dementia (=1).

2.4. Outcomes

The outcome of the study was functional decline, defined as a decline of at least one point on the Katz ADL score at discharge compared with on admission. The Katz ADL score is a measurement instrument for functional status containing six items: bathing, dressing, toileting, transferring, eating, and continence (Katz et al., 1963). Each item was scored 0 (dependent) or 1 (independent). The total score ranged from 0 (totally dependent) to 6 (independent).

2.5. Statistical analysis

Descriptive statistics were used to summarize patients' characteristics. For derivation of the model, possible predictors were entered into a multivariable model using backward stepwise binary logistic regression analysis by the Akaike Information Criterion (AIC). In the TRIPOD statement, excluding possible predictors with nonsignificant p values on univariate analysis is not recommended, because a nonsignificant unadjusted statistical association with the outcome does not necessarily imply that a predictor is unimportant (Moons et al., 2015). For internal validation, the performance of the model was investigated by calibration and discrimination. Calibration was assessed by a calibration plot. The Hosmer-Lemeshow test was not used because it could be nearly always significant (meaning poor calibration) for large samples (Kramer & Zimmerman, 2007). Discrimination was assessed by the c-statistic (area under the curve). For external validation, the model was assessed by calibration and discrimination in the two separate datasets

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