Journal of Epidemiology xxx (2016) 1–6

Contents lists available at ScienceDirect

Journal of Epidemiology

journal homepage: http://www.journals.elsevier.com/journal-of-epidemiology/

Validation of a novel claims-based stroke severity index in patients with intracerebral hemorrhage

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ARTICLE INFO

Article history:
Received 15 February 2016
Available online xxx

Keywords:
Administrative claims data
Stroke severity
Intracerebral hemorrhage
National Health Insurance Research Database
Outcomes research

ABSTRACT

Background: Stroke severity is an important outcome predictor for intracerebral hemorrhage (ICH) but is typically unavailable in administrative claims data. We validated a claims-based stroke severity index (SSI) in patients with ICH in Taiwan.

Methods: Consecutive ICH patients from hospital-based stroke registries were linked with a nationwide claims database. Stroke severity, assessed using the National Institutes of Health Stroke Scale (NIHSS), and functional outcomes, assessed using the modified Rankin Scale (mRS), were obtained from the registries. The SSI was calculated based on billing codes in each patient's claims. We assessed two types of criterion-related validity (concurrent validity and predictive validity) by correlating the SSI with the NIHSS and the mRS. Logistic regression models with or without stroke severity as a continuous covariate were fitted to predict mortality at 3, 6, and 12 months.

Results: The concurrent validity of the SSI was established by its significant correlation with the admission NIHSS ($r = 0.731$; 95% confidence interval [CI], 0.705–0.755), and the predictive validity was verified by its significant correlations with the 3-month ($r = 0.696$; 95% CI, 0.665–0.724), 6-month ($r = 0.685$; 95% CI, 0.653–0.715) and 1-year ($r = 0.664$; 95% CI, 0.622–0.702) mRS. Mortality models with NIHSS had the highest area under the receiver operating characteristic curve, followed by models with SSI and models without any marker of stroke severity.

Conclusions: The SSI appears to be a valid proxy for the NIHSS and an effective adjustment for stroke severity in studies of ICH outcome with administrative claims data.

1. Introduction

Intracerebral hemorrhage (ICH) remains a major challenge for public health. According to a large meta-analysis from 36 studies conducted worldwide between 1980 and 2008, the overall incidence of ICH is 24.6 per 100,000 person-years, with a median 30-day mortality of 40.4%, and only 12%–39% of patients are able to remain independent after ICH.[1] Despite the decrease in annual incidence of ICH from 2000 to 2010, the short- and long-term mortality following ICH did not change.[2] Stroke severity, assessed using a standardized stroke scale like the National Institutes of Health Stroke Scale (NIHSS), is an important outcome predictor for ICH.[3,4] Every one-point increase in the NIHSS leads to a 10% higher risk of poor 1-year functional outcome.[4]

Administrative claims data, which are derived from claims for routine clinical practices, often include demographic information,

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http://dx.doi.org/10.1016/j.je.2016.08.003

diagnoses, and claims for procedures, laboratory tests, and medications. They contain much clinical information and may be an efficient and affordable resource for ICH research. However, before conducting clinical studies using these data, it is essential to determine whether the available claims data could sufficiently reflect the clinical manifestations of a health condition. For example, several studies have focused on developing algorithms to identify subtypes of stroke using administrative claims data.[5] For the identification of presence of ICH, the algorithms in previous studies generally showed high positive predictive values, ranging from 79% to 97%.[5] Researchers are increasingly using administrative claims data to investigate risk factors,[6,7] epidemiologic trends,[8,9] and outcomes of ICH.[10–12] Nevertheless, administrative claims data usually do not contain information on stroke severity.[13,14] Therefore, stroke outcome studies based on administrative claims data alone may have inadequate adjustment for stroke severity.[15]

Recently, we developed a claims-based stroke severity index (SSI), which has been validated as an effective proxy for stroke severity in patients with acute ischemic stroke (AIS).[16] The SSI is significantly correlated with patient admission NIHSS scores. However, the validity of the SSI for ICH patients has not been determined. In this study, we validated the SSI in patients with ICH from three hospitals in Taiwan.

2. Methods

Overall, we linked stroke registry data with the National Health Insurance Research Database (NHIRD) using non-unique characteristics of a patient with ICH, as described previously.[16–18] We then computed SSI based on claims data of the NHIRD and evaluated the criterion-related validity of the SSI. Finally, we examined the change in model performance resulting from adding the SSI to models for predicting mortality after ICH.

2.1. Stroke registry data

We identified adult patients with an ICH diagnosis in stroke registries from the Chi Mei Medical Center, the Landseed Hospital, and the Ditmanson Medical Foundation Chiayi Christian Hospital. Patients with in-hospital stroke were excluded. The study hospitals registered all stroke patients admitted within 10 days of symptom onset following a protocol that has been reported elsewhere.[19] ICH was defined as "a non-traumatic abrupt onset of symptoms with relevant focal neurological deficit, with or without headache or altered level of consciousness, with a focal collection of blood within the brain parenchyma on computed tomography or magnetic resonance imaging that was not a hemorrhagic conversion of a cerebral infarction".[19] Stroke severity was determined using the NIHSS. The functional status of patients (who had provided prior written informed consent for follow-up) was evaluated using the mRS at 3 months, 6 months, and 1 year after ICH by in-person assessment or by telephone interview. To ensure patient anonymity, we retrieved only the gender, birth date, admission date, discharge date, NIHSS score at admission, and mRS scores at follow-up from the registry databases. The study protocol was approved independently by the Institutional Review Boards of the three participating hospitals.

2.2. National Health Insurance Research Database linkage

The National Health Insurance (NHI) program is a compulsory, single-payer healthcare program that covers virtually the entire population of Taiwan. The program provides universal coverage for prescription medications, inpatient care, and ambulatory care. The National Health Insurance Research Database (NHIRD), which consists of all administrative claims data on NHI enrollees, is maintained and released for research by the National Health Research Institutes of Taiwan. Traceable personal identifiers in the NHIRD were scrambled to protect patient privacy and confidentiality.[20]

To identify the inpatient population of ICH patients in the NHIRD, we extracted the data of all patients hospitalized between 2006 and 2010 for ICH (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] diagnosis code 431) as their principal or secondary discharge diagnosis from a stroke-specific NHIRD data set. Four non-unique patient characteristics (gender, birth date, admission date, and discharge date) were used to link registry data with the NHIRD.[16–18] If more than one patient in either the stroke registries or the NHIRD shared the same values in all four matching characteristics, they were excluded. Errors in coding or entering data in administrative claims data might also be present, which could cause the failure of linkage.[21] Successfully linked cases comprised the study cohort, and the linked hospitalization record in the NHIRD was defined as the index hospitalization.

2.3. Measurements

For each case in the study cohort, we extracted all the diagnosis codes from the index hospitalization, as well as inpatient and outpatient claims within the 1-year look-back period before the index hospitalization.[10,22] Patients were identified as having a comorbidity if its corresponding ICD-9-CM codes (eTable 1) appeared in at least one inpatient claim or three outpatient claims during the 1-year look-back period.[10,22] Severity of comorbidities was then summarized using a modified version of the Charlson comorbidity index (CCI),[23] which excluded cerebrovascular disease and hemiplegia. The modified CCI has been validated as a measure of comorbidity for predicting mortality and functional outcome in ICH patients[24] and was dichotomized into low comorbidity (<2) or high comorbidity (≥ 2) for analyses.[24]

Previously, the SSI was developed to predict patient NIHSS score at admission and was validated for AIS patients by linking registry data with the NHIRD.[16] The SSI contains seven predictors: airway suctioning, bacterial sensitivity test, general ward stay, ICU stay, nasogastric intubation, osmotherapy, and urinary catheterization (Table 1). Among all the AIS patients, the SSI was highly correlated with the admission NIHSS score.[16] The presence or absence of each predictor was determined using detailed billing codes (eTable 2) in claims data and was subsequently entered in a multiple linear regression equation (Table 1) to calculate the SSI for each patient.

The outcomes of interest, including patient NIHSS score at admission; functional outcomes assessed using the mRS at 3 months, 6 months, and 1 year after the index ICH; and mortality status were obtained from the registry databases.

Table 1
Multiple linear regression model for the stroke severity index.

Predictor	Coefficient
Airway suctioning	3.5083
Bacterial sensitivity test	1.3642
General ward stay	−5.5761
ICU stay	4.1770
Nasogastric intubation	4.5809
Osmotherapy (mannitol or glycerol)	2.1448
Urinary catheterization	1.6569
Constant	9.6804

ICU, intensive care unit.

Please cite this article in press as: Hung L-C, et al., Validation of a novel claims-based stroke severity index in patients with intracerebral hemorrhage, Journal of Epidemiology (2016), http://dx.doi.org/10.1016/j.je.2016.08.003