

Causes and Predictors for Hospital Readmission after Ischemic Stroke

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Background: Readmission after stroke is frequent, but limited data are available in Europe. This study aimed at assessing frequencies, causes, and factors associated with early and late unplanned readmissions within 1 year after discharge from ischemic stroke hospitalization. *Methods:* All surviving ischemic stroke patients admitted to the Department of Neurology, Haukeland University Hospital, Norway, between July 1, 2007, and June 30, 2012, were followed from discharge until August 1, 2012. Information on readmissions was collected by medical chart reviews. Logistic regression was performed to assess factors associated with early (≤ 90 days) and late (91-365 days) readmission. *Results:* Of 1175 patients discharged alive, 18.8% were readmitted within 90 days, and 24.5% were readmitted between day 91 and 365. Most frequent causes were infections, recurrent ischemic stroke, other cardiovascular events, and events related to index stroke. Early readmission was associated with older age, impaired physical function, atherosclerotic etiology of index stroke, and a higher risk factor burden. Late readmission was associated with older age and prior myocardial infarction. Early readmitted patients had shorter length of index admission, poorer physical function and higher frequencies of atherosclerotic etiology of index stroke, atrial fibrillation, and complications with infection during the index admission compared to patients readmitted late. *Conclusions:* Readmission after ischemic stroke is frequent, especially in the early period after discharge. Diagnoses and predictors varied according to time point for readmission, reflecting different underlying mechanisms for causes of readmission. Causes of early readmission may include a prothrombotic state and disposition for recurrent infections. **Key Words:** Readmission—rehospitalization—stroke—ischemic stroke—outcome research.

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Conditions leading to readmission of stroke survivors cause greater disability for the patient, increased mortality, and higher costs for the society.^{1,2} However, limited data are available regarding the burden on readmission after stroke, especially in Europe.

Within 1 year after discharge, 31%-49% of stroke survivors experience readmissions,³⁻⁶ and nearly half of the first readmissions occur within 90 days.⁶ Leading causes of readmission are infections, recurrent cerebrovascular events, and other cardiovascular diseases.⁵⁻⁷

Predictors of readmission after stroke might help prevent some of the complications and readmissions. Previously reported factors associated with readmission have been older age, impaired physical function,^{6,8-10}

increased length of index admission for stroke,^{3,6,10} complication during index admission,^{6,11} and comorbidities such as diabetes mellitus, prior stroke, coronary artery disease, and atrial fibrillation.⁶ Despite many attempts, there are no standardized models for predicting risk of readmission after stroke.¹²

The aims of this hospital-based cohort study were to (1) estimate frequencies of unplanned readmissions after discharge from ischemic stroke hospitalization, (2) determine the causes for readmission, and (3) investigate factors associated with readmission.

We hypothesized that the risk of readmission was high during the first 90 days after discharge, because some patients may be in a prothrombotic state, experience delayed hospital-acquired infections, or be prone to infections after ischemic stroke. We therefore investigated early (≤ 90 days) and late (91-365 days) readmissions separately.

Materials and Methods

All patients with acute ischemic stroke admitted to the Department of Neurology at Haukeland University Hospital between July 1, 2007, and June 30, 2012, were prospectively registered in the Bergen NORSTROKE Registry. The stroke unit serves a well-defined region of approximately 250,000 people. We obtained written informed consent from all patients. This study includes patients living in the local area of Haukeland University Hospital. Patients who died during index admission were excluded from the study.

Ischemic stroke was defined as a neurologic deficit lasting more than 24 hours or a clinically transient ischemic attack where computed tomography or magnetic resonance imaging showed infarctions related to the initial clinical symptoms.¹³ The National Institutes of Health Stroke Scale (NIHSS) score was used to assess stroke severity on admission and day 7. Short-term outcome was determined by modified Rankin Scale (mRS) and Barthel Index on day 7 (or at discharge if discharged earlier than 7 days). Electrocardiogram and duplex ultrasound of the carotid arteries were obtained. Stroke etiology was classified by the Trial of Org 10172 in Acute Stroke Treatment (TOAST) criteria.¹⁴ Clinical characteristics, medical history, and stroke cause were registered by a neurologist within 1 day after admission. The risk factor burden was defined by traditional risk factors as 0, 1, 2, and 3 or more risk factors. These included hypertension, diabetes mellitus, smoking, angina pectoris, peripheral vascular disease, and prior myocardial infarction. Other risk factors registered were prior cerebrovascular disease, atrial fibrillation, and prior coronary intervention. Complications during the index admission included urinary incontinence, urinary retention, urinary tract infection (UTI), pneumonia, seizures, and stroke in progression (NIHSS score worsening ≥ 4 points during the first

week after stroke onset compared to NIHSS score on admission). Secondary preventive treatment on discharge was based on the Norwegian guidelines for stroke treatment.¹⁵

Information regarding hospital readmissions after discharge from the index stroke until August 1, 2012, was collected by medical chart reviews. Outcome was defined as the first unplanned readmission. Subjects were dichotomized during follow-up as readmitted or not readmitted. When investigating frequencies, causes, and predictors of readmission, readmitted patients were divided into 2 groups: readmission ≤ 90 days (early readmission) and readmission 91-365 days (late readmission). Patients who could not be followed for the respective time intervals, and patients who were either dead or had been readmitted before the 91-365 days interval, were excluded from the respective intervals. Possible hospital-acquired infections were assessed by comparing the proportion of readmission with infections the first 30 days after discharge to day 31-60. A possible prothrombotic state was assessed by comparing the proportion of readmissions with recurrent ischemic stroke or myocardial infarction ≤ 90 to day 91-180.

The study was approved by the Western Regional Ethics Committee (REC).

Statistics

Proportions were used to describe frequencies and causes of readmission. Student *t* test, chi-square test, and Mann-Whitney *U* test were used to investigate baseline characteristics. Logistic regression analyses were performed to identify factors independently associated with early and late readmission. Analyses were performed by stepwise backward elimination where first step included all parameters that turned out significant ($P < .05$) in the univariate analyses. Age, sex, and mRS were forced into each regression to adjust for potentially confounding factors. Kaplan-Meier was performed to illustrate readmission and survival based on etiology. Statistical analyses were performed with Stata 12.0 (Stata Corporation, College Station, TX, USA).

Results

A total of 1250 patients were admitted with acute ischemic stroke between July 1, 2007, and June 30, 2012. During the index admission, 75 (6.0%) patients died. Thus, 1175 patients were discharged alive and included in the study.

Frequencies and Causes of First Unplanned Readmission

Frequencies and causes of first unplanned readmission are presented in Table 1. Of all patients who could be followed for 1 year after discharge ($n = 943$), 355 (37.7%) had

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