

A Simple Prediction Score for Developing a Hospital-Acquired Infection after Acute Ischemic Stroke

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Background: Hospital-acquired infections (HAIs) are a major cause of morbidity and mortality in acute ischemic stroke patients. Although prior scoring systems have been developed to predict pneumonia in ischemic stroke patients, these scores were not designed to predict other infections. We sought to develop a simple scoring system for any HAI. **Methods:** Patients admitted to our stroke center (July 2008-June 2012) were retrospectively assessed. Patients were excluded if they had an in-hospital stroke, unknown time from symptom onset, or delay from symptom onset to hospital arrival greater than 48 hours. Infections were diagnosed via clinical, laboratory, and imaging modalities using standard definitions. A scoring system was created to predict infections based on baseline patient characteristics. **Results:** Of 568 patients, 84 (14.8%) developed an infection during their stays. Patients who developed infection were older (73 versus 64, $P < .0001$), more frequently diabetic (43.9% versus 29.1%, $P = .0077$), and had more severe strokes on admission (National Institutes of Health Stroke Scale [NIHSS] score 12 versus 5, $P < .0001$). Ranging from 0 to 7, the overall infection score consists of age 70 years or more (1 point), history of diabetes (1 point), and NIHSS score (0-4 conferred 0 points, 5-15 conferred 3 points, >15 conferred 5 points). Patients with an infection score of 4 or more were at 5 times greater odds of developing an infection (odds ratio, 5.67; 95% confidence interval, 3.28-9.81; $P < .0001$). **Conclusion:** In our sample, clinical, laboratory, and imaging information available at admission identified patients at risk for infections during their acute hospitalizations. If validated in other populations, this score could assist providers in predicting infections after ischemic stroke. **Key Words:** Infection—acute ischemic stroke—outcome—risk factors—modeling.

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Received October 16, 2014; accepted November 14, 2014.

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A.K.B. was supported by NINDS NIH T32 NS007153-31. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NINDS or the NIH. This study was conducted at Tulane Medical Center.

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1052-3057/\$ - see front matter

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<http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2014.11.014>

Hospital-acquired infections (HAIs) are a major cause of morbidity and mortality among patients admitted with an ischemic stroke.¹ The National Healthcare Safety Network defines an HAI, or nosocomial infection, as a “localized or systemic condition that is preventable and results from an adverse reaction to the presence of an infectious agent with no evidence that the infection was present or incubating at the time of admission to the acute care setting.”² Postischemic stroke infections are particularly problematic because they increase the risk of death and disability after discharge through fever, immobilization of the patient, and end-organ damage resulting from shock.^{3,4} Furthermore, infections are known to complicate ischemic stroke recovery by increasing hospital costs and by prolonging hospitalization.⁵⁻⁷

Although patient-related factors such as stroke severity and age are indicators of outcome following acute ischemic stroke (AIS), HAIs may also play a long-term role.⁸⁻¹⁰ Prior research has shown that infections present on admission (POA) are not associated with poor outcomes after ischemic stroke, whereas HAIs are a major contributor to poor functional outcomes.¹¹ Urinary tract infection (UTI), pneumonia (PNA), and bacteremia are among the most common types of HAI, presenting a barrier to long-term recovery in this population.^{6,12} Together, these 3 infection types comprise nearly half of all HAIs.¹³

Early identification of risk factors for infection during hospitalization for AIS is important, considering effective management may prevent the development of an HAI and subsequently improve long-term outcomes, although this remains controversial.¹⁴⁻¹⁶ Prior research has shown that infections occur more commonly in the acute phase after ischemic stroke.¹⁷ Several investigators have identified risk factors for hospital-acquired PNA after stroke and prediction models have been generated,^{18,19} but to date, no model has been generated to assess the risk of any nosocomial infection. The purpose of this study was to develop a simple risk prediction model useful in a broad spectrum of infection subtypes in patients hospitalized for AIS.

Methods

Study Population

A retrospective analysis of previously collected data of all patients with AIS who presented to our single academic institution between July 2008 and June 2012 was performed using previously described methods.²⁰ The registry includes demographic variables, baseline clinical, laboratory, medication, and imaging variables, as well as inpatient clinical, laboratory, medication, and imaging variables on all patients admitted with a stroke. Patients were excluded if they were last seen normal more than 48 hours before admission, had an unknown time of last seen normal, were transferred to our center from an

outside hospital, experienced an in-hospital stroke, or had an infection POA (defined as an infection diagnosed within the first 24 hours of admission).

Definition of Outcomes

All-cause HAIs were defined as any type of bacterial, fungal, or viral infection. Infection types not included in the detailed scoring mechanisms (eg, cellulitis, pseudomembranous colitis, meningitis, ventriculitis) were diagnosed clinically or via laboratory/imaging findings. Subsequent analyses were performed to assess predictors of UTI, PNA, and bacteremia. UTIs were defined as more than 100,000 colony-forming units per millimeter of urine in a patient with signs and symptoms. Urinalysis, which is ordered for all patients on admission as part of a standardized order set, distinguishes HAI from bacteriuria POA. PNA was defined as an infiltrate on chest radiography with appropriate clinical correlates, but is considered POA (and therefore excluded) if identified on baseline chest radiography, which is also part of a standardized admission order set.²¹ Bacteremia was defined as more than 100,000 colony-forming units in at least 2 venous blood samples (excluding contaminants). We considered coagulase-negative staphylococci, diphtheroids, *Micrococcus* spp., *Bacillus* spp., and viridans group streptococci as contaminants if these bacteria did not grow out of all available blood culture vials from a given date and time (eg, if only 1 of 2 blood culture vials speciated the organism).

Statistical Analysis

We compared admission variables of interest between patients who contracted an HAI and those who did not contract an HAI. The Pearson chi-square (or the Fisher exact test where appropriate) was used to compare proportions. The Wilcoxon rank sum test was used to compare medians of continuous data. A prediction score for HAIs was created by dividing the patient sample into a random sample of 55% of the data set (build group). The remaining 45% constituted the test group. Once the score was tested in the test group, the score was tested in the entire data set. Logistic regression models were used to assess the association between admission variables and the outcome of interest, HAI. Every variable collected at the time of admission as part of the registry was tested in a univariable logistic regression model to assess whether it was an independent predictor of HAIs. Independent predictors of HAIs (eg, age, history of diabetes) with *P* values .2 or less were considered for the final score as score variables and were evaluated at different values and dichotomizations by calculating the sensitivity and specificity of each binary exposure. Further testing on the categorized variable through crude logistic regression models to identify cutoff points was conducted. Each continuous variable was evaluated using receiver

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