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Predictors of 30 Day Readmission after Intracerebral Hemorrhage: A single-center approach for identifying potentially modifiable associations with readmission

Eric M. Liotta, MD¹, Mandeep Singh, MD², Adam R. Kosteva, MA¹, Jennifer L. Beaumont, MS³, James C. Guth, MD¹, Rebecca M. Bauer, MD MPH², Shyam Prabhakaran, MD MS¹, Neil F. Rosenberg, MD¹, Matthew B. Maas, MD^{1,2}, and Andrew M. Naidech, MD MSPH^{1,2}

¹Department of Neurology, Northwestern University—Feinberg School of Medicine, Chicago, IL

²Department of Anesthesiology, Northwestern University—Feinberg School of Medicine, Chicago, IL

³Department of Medical Social Sciences, Northwestern University—Feinberg School of Medicine, Chicago, IL

Abstract

Objective—To determine if patient demographics or severity of illness predict hospital readmission within 30 days following spontaneous intracerebral hemorrhage (ICH), to identify readmission associations that may be modifiable at the single center level, and to determine the impact of readmission on outcomes.

Design—We collected demographic, clinical, and hospital course data for consecutive patients with spontaneous ICH enrolled in an observational study. Readmission within 30 days was determined retrospectively by an automated query with manual confirmation. We identified the reason for readmission and tested for associations between readmission and functional outcomes using modified Rankin Scale (mRS, a validated functional outcome measure from 0, no symptoms to 6, death) scores before ICH and at 14 days, 28 days, and three months after ICH.

Setting—Neurologic intensive care unit of a tertiary care hospital.

Patients—Critically ill patients with spontaneous ICH.

Interventions—Patients received standard critical care management for ICH.

Corresponding Author: Andrew M. Naidech, 710 N Lake Shore Drive, Abbott Hall 1116, Chicago, IL 60611, Tel: 312-908-5633, Fax: 312-908-5073, a-naidech@northwestern.edu.

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Measurements and Main Results—Of 246 patients (mean age 65 years, 51% female), 193 (78%) survived to discharge. Of these, 22 (11%) were re-admitted at a median of 9 [interquartile range (IQR) 4–15] days. The most common readmission diagnoses were infections after discharge (N=10) and vascular events (N=6). Age, history of stroke and hypertension, severity of neurologic deficit at admission, APACHE acute physiology score, ICU and hospital length of stay, ventilator free days, days febrile, and surgical procedures were not predictors of readmission. History of coronary artery disease was associated with readmission ($p=0.03$). Readmitted patients had similar mRS and severity of neurologic deficit at 14 days but higher (worse) mRS scores at three months (median [IQR], 5 [3–6] vs. 3 [1–4], $p=0.01$).

Conclusions—Severity of illness and hospital complications were not associated with 30-day readmission. The most common indication for readmission was infection after discharge, and readmission was associated with worse functional outcomes at three months. Preventing readmission after ICH may depend primarily on optimizing care after discharge and improve functional outcomes at three months.

Keywords

Intracerebral hemorrhage; critical care; readmission; quality metric; outcomes

Introduction

Rates of hospital readmission have become a metric of hospital and provider performance as well as a means by which to incentivize efficient, high quality, and coordinated patient care (1,2). The direct economic cost of unplanned Medicare readmissions in 2004 was estimated in excess of \$17 billion (3), and each readmission within the first 30 days may be associated with a substantially increased health care cost over the subsequent year (4). Beginning October 1st, 2012, the United States Government, under the Patient Protection and Affordable Care Act, began penalizing hospitals up to 1% of their Medicare reimbursement based on rates of readmission within 30 days for myocardial infarction, congestive heart failure, and pneumonia with plans to gradually increase the penalty cap to 3% and expand the conditions covered to include joint replacement, vascular stenting, cardiac bypass, and stroke (including intracerebral hemorrhage) by 2015 (1). These financial penalties have spurred hospital administrators to identify patients at risk of readmission and develop interventions to reduce rates of readmission within 30 days.

Among neurologic patients, the literature on readmission has focused almost exclusively on ischemic stroke. The few data available on patients with spontaneous intracerebral hemorrhage (ICH), a form of hemorrhagic stroke involving hemorrhage in to the brain parenchyma not due to a pre-existing structural lesion, is derived from the medicare population and suggests a uniformly high (>15%) rate of readmission within 30 days, even in stroke centers (5). The rate of readmission for all-comers after ICH is not well known. The majority of ischemic stroke readmission studies have relied on large administrative databases, which are subject to the limitations of non-specific diagnostic codes and surrogate measures of disease severity, and the few hospital based studies addressing the issue have included only limited data on disease severity, hospital course, and outcomes (4, 6–9). In addition, while large administrative databases have the benefit of being adequately powered to detect small associations with readmission not all associations can be equally well investigated in an administrative database and it can be difficult to determine which of these associations are of sufficient magnitude to be clinically meaningful in a manner that can be incorporated in an individual institution's strategy to reduce readmission rates. We sought to use our single-center ICH cohort to develop a method for identifying and interpreting associations between demographic, clinical, and hospital course features and hospital

readmission within 30 days that would be clinically meaningful for quality improvement efforts at the individual institution level. We also sought to examine the relationship between readmission and functional outcomes in a population of critically ill patients with spontaneous ICH.

Materials and Methods

Patients presenting to our institution with ICH between December 2006 and July 2012 were enrolled in a prospective observational cohort registry. The diagnosis of spontaneous ICH was made by a board-certified vascular neurologist or neurointensivist using CT and/or MR imaging in each case. Cases of ICH attributed to trauma, hemorrhagic conversion of ischemic stroke, structural lesions, or vascular malformations were excluded because ICH secondary to these causes likely represents several entities with unique pathophysiologic mechanisms, patient demographics, comorbidities, and expected natural histories different than those of hemorrhagic stroke.

All patients were admitted to a neurologic sciences intensive care unit and received standardized care using an electronic order set. Our institutional protocol calls for a multidisciplinary approach in which each spontaneous ICH patient is evaluated by neurointensivist or vascular neurology and neurosurgical services. Surgical intervention is offered on a case by case basis to those patients whom the attending neurosurgeon believes are appropriate surgical candidates.

We retrospectively identified patients re-admitted to our institution within 30 days of discharge by an automated query of our hospital's database with confirmation from manual review of the electronic medical record. Under current rules, patients readmitted for scheduled procedures and planned admissions were not included.

Demographic information, medical history, standardized clinical scales (Glasgow Coma Scale [GCS], National Institute of Health Stroke Scale [NIHSS], ICH score, and pre-morbid modified Rankin Scale [mRS]), imaging data, surgical interventions, medical complications, and key aspects of the hospital course were captured in the observational cohort study using standardized electronic forms. The GCS is a standardized exam scale with values ranging from deepest coma or death (GCS 3) to normal exam (GCS 15). The NIHSS is a scale based on a standardized neurologic examination with scores ranging from a normal exam (NIHSS 0) to the most severe neurologic impairment (NIHSS 42). Both the GCS and NIHSS are widely used methods of quantifying the severity of neurologic exam deficits in stroke clinical practice and research and their routine use is advocated by guidelines from the American Heart Association/American Stroke Association (10–11). The ICH score is obtained by assigning points for the presence of each of five factors: age over 80 years, ICH volume over 30 mL, presence of intraventricular hemorrhage, presence of infratentorial hemorrhage, and severity of GCS (between 0 and 2 points may be assigned depending on severity of GCS score). The ICH score is a widely used and validated prognostic scale in spontaneous ICH with scores ranging from 0 to 6 and a score of 6 being associated with the highest mortality rate (12–13). The mRS is a method of quantifying degree of disability and scores range from 0, no symptoms, to 6, dead. The mRS is a validated, reliable, and widely used method for evaluating stroke patient outcomes and as an end point in clinical trials (14).

Our institution began collecting and documenting Acute Physiology Age Chronic Health Evaluation (APACHE) IV (15) data on all patients admitted to an ICU starting in 2010. APACHE IV is an evaluation system for quantifying severity of illness, predicting outcomes, and comparing outcomes against national averages for ICU patients (15). We

recorded APACHE IV data, including Acute Physiology Score and APACHE IV expected ICU length of stay in the observational cohort after January 1, 2010. NIHSS and mRS were determined at 14 days post-ICH or at the time of initial discharge if prior to 14 days by a certified examiner independent of the patient's primary clinical team. The mRS was also recorded at 28 days and three months post-ICH. The mRS scores were obtained using a structured interview format of the mRS as developed and described by Wilson et al (16–17). Interviews were performed by a certified examiner by telephone. Telephone acquisition of the mRS has been found to have good agreement with face-to-face acquisition and the mRS has been validated against other quality of life scales (14, 18–20). Initial hematoma volumes were obtained on industry standard DICOM images using Analyze software (Mayo Clinic, Rochester, MN) and a semi-automated process, a high reliability technique used in previous ICH studies, as previously described (21). Prior to discharge from the index hospitalization, the attending vascular neurologist or neurointensivist documented the most probable underlying etiology for each patient's spontaneous ICH. Reasons for readmission as well as presence or absence of indwelling urinary or venous catheters at time of readmission were abstracted from review of the electronic medical record. The presence of pneumonia during initial hospitalization and readmission was identified using the Centers for Disease Control and Prevention criteria (22).

We assessed for differences in baseline demographic, clinical, and hospital course variables and outcomes between patients who were readmitted and those not readmitted by chi square test for categorical variables, Student's t test for normally distributed continuous variables, and Mann-Whitney U test for ordinal variables and non-normally distributed continuous variables. We assessed for variables associated with readmission within 30 days on univariate analysis. Too few variables were found to be significant on univariate analysis to pursue a meaningful multivariate analysis of independent predictors of readmission. We also compared APACHE IV expected ICU length of stay to actual ICU length of stay in those patients with available data in order to identify if potentially pre-mature de-escalation of care was associated with 30-day readmission. Statistical calculations were made using standard commercial software (MiniTab v. 15, State College, PA).

The study was approved by the Institutional Review Board. Written informed consent was obtained from the patient or their legally authorized representative. A waiver of consent was approved for patients who died during initial hospitalization, or who were incapacitated and for whom a legal representative could not be located.

Results

There were 246 consecutive patients (mean age 65 years, 51% female, median ICH score 1, median admission NIHSS 11) admitted and 193 (78%) survived to discharge. Of survivors, 22 (11%) were readmitted within 30 days of initial discharge with a median time to readmission of 9 (interquartile range [IQR] 4–15) days. Table 1 shows demographic data, stratified by readmission. In univariate analysis, coronary artery disease (32% versus 14%, $p=0.03$) and premorbid functional disability (mRS median [IQR]: 0 [0–2] versus 0 [0–0], $p=0.02$) were more prevalent in patients readmitted within 30 days. Table 2 shows the clinical measures and hospital course data stratified by readmission within 30 days. Of note, admission Glasgow Coma Score and NIHSS, ICH score, APACHE acute physiology score, presence of intraventricular hemorrhage, and ICH volume and location were not different between patients who were readmitted and those who were not ($P>0.15$ for all). The two groups also did not differ in terms of ventilator free days or rates of ICH-related surgical procedures, though there was a trend ($p=0.15$) towards more febrile days within 14 days (3 [1–6] versus 1 [0–4] days, $p=0.08$) and higher rates of pneumonia (23% versus 11%, $p=0.1$) in readmitted patients.

Among patients not readmitted hypertension (61%) was the probable underlying etiology for spontaneous ICH most frequently assigned by the neurointensivist followed by amyloid angiopathy (16%) and then anticoagulant use (9%). Hypertension (86%) was the most frequently assigned underlying etiology for spontaneous ICH in readmitted patients and was followed in frequency by anticoagulation and amyloid angiopathy (both 5%). There was not a statistically significant difference in assigned underlying etiology between readmitted and not readmitted patients ($p=0.5$). Chart review of surgical notes revealed that the most frequently documented indication for craniotomy was decompressive hemicraniectomy for treatment of life-threatening herniation and elevated intracranial pressure (13 patients) and this was followed by 2 patients each for decompressive hemicraniectomy for impending neurologic deterioration, deep hematoma evacuation for worsening neurologic exam, and superficial hematoma evacuation.

The most common reason for readmission was infection after hospital discharge (10 patients) followed by vascular events (six patients), including two patients with ischemic stroke. Only three readmissions were for catheter-associated infections, including two for urinary catheter-associated infections and one for peripherally inserted central catheter-associated infection. Reasons for readmission are summarized in Table 3.

Patient discharge disposition and length of stay data are shown in Table 4. Patients who were readmitted did not have different ICU lengths of stay or initial discharge dispositions compared to those not readmitted, though there was a trend towards longer initial hospital lengths of stay (13.1 [8.5–20.3] versus 10.0 [5.0–19.6] days, $p=0.1$) in readmitted patients. In the subset of patients for whom APACHE data was available, APACHE IV-expected ICU lengths of stay for readmitted patients (10 patients) were not significantly different than the actual ICU lengths of stay (5.3 [4.7–5.7] versus 5.7 [4.2–6.9] days, $p=0.8$). Patients who were not readmitted (59 patients) had significantly longer expected than actual ICU lengths of stay (4.7 [4.1–6.3] versus 3.2 [2.0–8.6] days, $p=0.02$). NIHSS (6 [3–16] versus 11 [5–17], $p=0.1$) and mRS (4 [4–5] versus 5 [4–5], $p=0.2$) were not significantly different at 14 days post-ICH between not readmitted and readmitted patients. Fourteen day, 28 day and three month function outcome data are shown in Figure 1. Functional outcomes were different at 28 days (mRS 5 [4–5] versus 4 [3–5], $p=0.02$) and three months (mRS 5 [3–6] versus 3 [1–4], $p=0.01$), and patients readmitted within 30 days had higher mortality at three months (30% versus 10%, $p=0.02$).

Discussion

In this single-center cohort of patients with spontaneous ICH, we found that readmission within 30 days was common (11%), most frequently due to infections acquired after hospital discharge, and unrelated to ICH severity or features of the initial hospitalization. These data suggest that while readmission is common, individual hospitals may be limited in their ability to prevent readmissions unless they can influence the patient's care after hospital discharge.

A minority of readmissions (23%) were for reasons likely to be iatrogenic or related to complications of interventions during the initial hospitalization, namely catheter-associated infections and neurosurgical intervention. Pneumonia is a well recognized cause of morbidity and mortality following ICH (23–25) and accounted for 14% of readmissions in our cohort, similar to the rate (14%) seen in ischemic stroke readmissions (6). Preventing pneumonia may be difficult, even with recommended procedures in place (26).

Severity of ICH and features of the initial hospitalization were not significant predictors of readmission within 30 days in our cohort, and among baseline demographic variables, only a

history of coronary artery disease and premorbid functional disability predicted readmission. These findings contrast against studies of patients with ischemic stroke that have inconsistently associated readmission with age, race, longer hospital stay, stroke severity, and discharge disposition but agree with findings of greater readmission rates in those patients with coronary artery disease (7, 9, 27). Organized follow-up interventions with an emphasis on early evaluations by medical professionals and facilitated patient and caregiver communication have been shown to reduce readmission rates in acute stroke patients (28); our data suggest that targeting such interventions at ICH patients with a history of coronary artery disease or moderate pre-morbid disability may be of particular benefit in reducing readmission rates and should be investigated further. The standard practice of discontinuing antiplatelet therapy following ICH may also predispose to readmission by acutely increasing the risk of subsequent ischemic vascular events in those patients with a high risk of comorbid coronary artery disease. The risk-benefit ratio of antiplatelet therapy after ICH for the prevention of ischemic stroke and ischemic heart disease remains unclear (29–31), but appropriately timed re-initiation of antiplatelet therapy in high risk patients might reduce rates of readmission for ischemic disease if it can be administered safely to this population. The safety and ideal timing of antiplatelet therapy re-initiation remains an area for investigation.

A major limitation of our study is that it was performed at a single tertiary level stroke center and associations identified in our cohort may not generalize to all institutions. It is possible that some institutions might identify associations with ICH readmission that are unique to their level of acuity and particular circumstances. Our use of standardized treatment protocols and guideline driven ICH management as well as a rate of readmission similar in magnitude to that at other certified stroke centers (5) suggests that our findings are likely to apply to other tertiary level stroke centers. We discovered that a significant factor in readmission was likely to be care after discharge, and it may be the case for any metropolitan hospital, where a recently discharged patient may present to one of several health care providers for follow up and continued care, that the efforts of any single hospital to influence medical evaluation and care after discharge will be limited unless there is a defined relationship between hospitals and providers of after discharge care.

Our cohort was sizable for a single center study but it was not of comparable size to the administrative databases that dominate the ischemic stroke readmission literature and as such may not be powered to identify the smaller magnitude associations an administrative database could uncover. This represents a trade-off between the number of patients that can be studied, the detail in which the patients can be studied, the ability to ensure individual patients are accurately classified, and the ability to identify associations of greater clinical meaningfulness. We believe that our cohort, which represents years worth of ICH admissions for most major medical centers, was of adequate size to demonstrate a method for identifying associations that are clinically meaningful for the development of targeted interventions to reduce readmission rates at the individual institution level. It is unlikely that a variable which fails to reach statistical significance in a cohort of our size will be strong enough to meaningfully impact readmission rates through targeted interventions. There remains a need for future studies using administrative databases to identify epidemiologic associations between spontaneous ICH and hospital readmission that are below the detection threshold of our study.

Our study was also limited in that APACHE data was not available for the entire cohort. It is possible that premature de-escalation of care could contribute to hospital readmission rates. However, we do not feel this is a significant confounder in our study because among patients with APACHE IV ICU length of stay predictions readmitted patients did not have shorter than expected ICU stays. Strengths of this dataset include the observational cohort

design for identifying patients and assessing functional outcomes after discharge, electronic methods for detecting readmission with confirmation of the proximate cause, and assessment of functional outcomes after discharge.

Conclusions

In patients with spontaneous ICH, readmission within 30 days was most commonly due to infection acquired after hospital discharge, while severity of neurologic injury and hospital complications were not associated with readmission. Readmission within 30 days was associated with worse functional outcomes at 28 days and three months, and higher mortality at three months. Our method for identifying associations with readmission in spontaneous ICH suggests that it may be difficult for individual institutions to identify patients likely to be readmitted during the index hospital stay and reducing the incidence of post-discharge infections and readmissions may depend on the ability to influence care after hospital discharge.

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Figure 1.

Fourteen-day, twenty-eight day, and three month function outcomes for patients readmitted within 30 days and those not readmitted expressed as medians and interquartile ranges.

*Follow up data was available for all patients at 14 days, for all readmitted patients and 84% of not readmitted patients at 28 days, and for 91% of readmitted patients and 74% of not readmitted patients at three months.

Table 1

Baseline demographic data for patients readmitted within 30 days and those not readmitted.

Demographics	Not Readmitted	Readmitted	P-value
Age (years) mean (SD)	62.7 (13.6)	67.3 (12.9)	0.1
Sex			0.7
Female	84 (49%)	10 (45%)	
Race			0.8
White	67 (39%)	9 (41%)	
Black	82 (48%)	12 (55%)	
Hispanic	15 (9%)	1 (5%)	
Historical Alcohol Abuse	17 (10%)	2 (9%)	0.9
Atrial Fibrillation	11 (6%)	3 (14%)	0.2
Coronary Artery Disease	24 (14%)	7 (32%)	0.03
Diabetes Mellitus	38 (22%)	7 (32%)	0.3
Historical Hypertension	129 (75%)	18 (82%)	0.5
History of TIA or Stroke	20 (12%)	5 (23%)	0.1
Reported Anticoagulant Use	14 (8%)	4 (18%)	0.1
Reported Antiplatelet Use	55 (32%)	9 (41%)	0.4
Pack years smoking, Median [IQR]	0 [0–19]	0 [0–0]	0.2
Pre-morbid modified Rankin Scale score			0.02
0	138 (81%)	13 (59%)	
1	15 (9%)	2 (9%)	
2	4 (2%)	3 (14%)	
3	2 (1%)	3 (14%)	
4	12 (7%)	1 (4%)	
5	0	0	

SD=standard deviation, TIA=transient ischemic attack, IQR=interquartile range

Table 2

Clinical characteristics and hospital course data for patients readmitted within 30 days and those not readmitted.

Clinical Characteristic	Not Readmitted	Readmitted	P-value
Initial GCS, median [IQR]	14 [10–15]	14 [10–15]	0.8
Initial GCS 8, N (%)	32 (19%)	4 (18%)	1
Admission NIHSS, median [IQR]	7 [3–16]	11 [3–19]	0.4
Initial ICH Score, median [IQR]	1 [0–1]	1 [0–1]	1
APACHE Acute Physiology Score *	32 [20–45]	30 [20–44]	1
APACHE IV Predicted ICU LOS (days) *	4.7 [4.1–6.3]	5.3 [4.7–5.7]	0.1
Initial ICH Volume (cm ³), median [IQR]	10 [4–20]	8 [4–24]	0.7
ICH location, n(%)			
Lobar	62 (36%)	6 (27%)	0.4
Non-Lobar	110 (64%)	16 (73%)	
Thalamus	44 (26%)	9 (41%)	
Cerebellar	10 (6%)	1 (4%)	
Lentiform Nucleus	35 (20%)	4 (18%)	
Caudate	7 (4%)	0 (0%)	
Brainstem	6 (3%)	1 (4%)	
Other	8 (5%)	1 (4%)	
Intraventricular Hemorrhage Present	67 (39%)	9 (41%)	1
Admission INR, median [IQR]	1.1 [1–1.2]	1 [1–1.1]	0.8
Ventilator Free Days in First 14 days of Initial Admission, median [IQR]	14 [6–14]	13 [6–14]	0.7
Days Febrile within 14 days of ICH onset, median [IQR]	1 [0–4]	3 [1–6]	0.08
Pneumonia During Initial Admission, n (%)	19 (11%)	5 (23%)	0.1
Craniotomy During Initial Admission, n (%)	22 (13%)	3 (14%)	0.9
Extraventricular Drain During Initial Admission, N (%)	38 (22%)	7 (32%)	0.3

Clinical Characteristic	Not Readmitted	Readmitted	P-value
Percutaneous Endoscopic Gastrostomy Tube During Initial Admission, n (%)	43 (25%)	7 (32%)	0.5
Tracheostomy During Initial Admission, n (%)	36 (21%)	6 (27%)	0.5

GCS=Glasgow coma score, IQR=interquartile range, NIHSS=National Institute of Health Stroke Scale, ICH=Intracerebral Hemorrhage, APACHE= Acute Physiology Age Chronic Health Evaluation, LOS=Length of Stay

* APACHE IV data was only available at our institution for patients admitted after January 1st 2010, which constitutes 10 readmitted and 59 not-readmitted patients in this cohort.

Table 3

Categories and numbers of each reason for 30 day readmission.

Readmission Diagnosis Category	Number of Patients
Infection	10
Pneumonia	3
Urinary Tract Infection	
Catheter-associated	2
Not catheter-associated	3
Bacteremia/Sepsis	
Catheter-associated	1
Not catheter-associated	1
Vascular Event	6
Ischemic Stroke	2
Ischemic Coronary Disease	2
Ruptured Abdominal Aortic Aneurysm	1
Hypertensive Urgency	1
Metabolic derangement	2
Gastrointestinal Bleed	1
Hydrocephalus	1
Seizure	1
Craniotomy exploration, inflammatory cyst evacuation, cranioplasty	1

Table 4

Discharge disposition and lengths of stay for patients readmitted within 30 days and those not readmitted.

	Not Readmitted	Readmitted	P-value
Initial Discharge Disposition, n(%)			0.4
Acute Care Facility	19 (11%)	1 (4%)	
Nursing Facility	28 (16%)	6 (27%)	
Rehabilitation	88 (52%)	12 (55%)	
Home	36 (21%)	3 (14%)	
ICU Length of Stay (Days), median [IQR]	4.9 [1.9–10.3]	6.6 [3.2–13.2]	0.2
Hospital Length of Stay (Days), median [IQR]	10.0 [5.0–19.6]	13.1 [8.5–20.3]	0.1

ICU=intensive care unit, IQR=interquartile range