Early Magnetic Resonance Imaging Decreases Hospital Length of Stay in Patients with Ischemic Stroke

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Background: Imaging modalities are important part of stroke evaluation. Noncontrast head computed tomography (CT) is the initial imaging modality in acute stroke and although important to rule out acute hemorrhage and making a decision on thrombolytic treatment, ischemic changes may not be visible on CT for up to 24 hours. Magnetic resonance imaging (MRI) brain is an invaluable tool to confirm an ischemic stroke and facilitates stroke evaluation. *Objective of this study was to investigate the correlation between time to MRI and length of hospital stay. Methods:* A total of 432 patients admitted to Hartford Hospital (Comprehensive Stroke Center) with a focal neurological deficit in the year 2014 and got a CT head and MRI brain were enrolled in the study. Data collection was done via stroke database and retrospective chart review. Patients with any hemorrhage or age <18 years were excluded from the study. Patients were categorized as having had an early (within 12 hours) or a late (more than 12 hours) MRI. We used chi-square and Wilcoxon ranked sum test to compare time from arrival to MRI and length of stay in the hospital. *Results:* There was a statistically significant difference in hospital length of stay between patients who obtained MRI within 12 hours, as compared with patients who had MRI greater than 12 hours after admission, early MRI group 3 days (1.8, 4.9) versus 4 days (2.6, 7.0), $P < .001$. *Conclusions:* Our study suggests that brain MRI performed within 12 hours of admission facilitates stroke evaluation and decreases hospital length of stay. It provides evidence for cost effectiveness of MRI in ischemic stroke.

Key Words: Early MRI—ischemic stroke—hospital length of stay

Introduction

Acute stroke management in a patient presenting with focal neurologic deficits includes obtaining neuroimaging, most commonly a noncontrast head computed tomography (CT) to determine eligibility for thrombolytic therapy.[1] While a head CT rules out acute intracranial hemorrhage, it provides limited information on whether the focal deficits are due to ischemic stroke or stroke mimics.[2] On the other hand, magnetic resonance imaging (MRI) is an excellent modality for diagnosis of acute ischemic stroke with sensitivity of 94%-100% on diffusion-weighted imaging (DWI) sequences within 30 minutes of onset of ischemia.[3] However, obtaining a brain MRI takes time and most hospitals do not have more than one scanner to incorporate a rapid short MRI protocol.[4] Current American Heart Association (AHA) guidelines recommend that a head CT scan should be performed within 20 minutes of arrival to the emergency department to rule

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out intracranial hemorrhage.[5,6] However, current guidelines do not recommend routine use of brain MRI for initial diagnosis of acute ischemic stroke.[6] This has been based predominantly on systematic reviews with meta-analyses and decision analytic models that have failed to show cost effectiveness of brain MRI in acute ischemic stroke.[6-8] However, it is well known that not only does MRI brain assist in accurate diagnosis of stroke and exclusion of stroke mimics,[9] but also importantly assists the clinician in determination of stroke etiology to influence stroke management.[10] It is perceivable that diagnostic challenges delay management and may lead to increased hospital length of stay (LOS). Increased hospital LOS in turn increase health care costs. The objective of this study was to determine if the early acquisition of MRI for the diagnosis of stroke decreases LOS.

Methods

A retrospective study was performed at Hartford Hospital using the stroke database. Hartford Hospital is a comprehensive stroke center and had 1277 inpatient stroke admissions in 2014. For study eligibility, we considered all adult patients (age ≥ 18 years) who presented to the emergency department between January, 2014 and December, 2014 with focal neurologic deficits who underwent a head CT on presentation and an MRI brain during their hospitalization. Patients with an intracerebral hemorrhage, subarachnoid hemorrhage, or subdural hematoma seen on imaging (292 patients with hemorrhage) or those with new focal deficits during hospitalization were excluded from the study. After those exclusions, 432 patients were included in the study.

The data were primarily obtained from a prospective stroke patient registry and were complemented by manual chart review for MRI timings and LOS.

Patients were categorized as having had an early (within 12 hours) or a late (more than 12 hours) MRI. Patients within the 2 groups were initially compared for baseline characteristics including demographics, stroke risk factors and other medical comorbidities, stroke and other variables pertaining to hospitalization. Key outcomes included hospital LOS, mortality, and discharge disposition.

Statistical analyses was performed using chi-square tests of proportion for dichotomous and categorical data variables; *t* tests for independent groups for continuous variables meeting assumptions of normality; and Wilcoxon ranked sum tests for continuous variables that did not meet the assumption of normality, such as LOS and for ordinal variables. The unit of analysis was the stroke admission; 13 patients had 2 admissions during the study period. SPSSv21 was used for all analyses; significance level, *P*, was set at .05.

Results

A total of 1143 patient admissions for ischemic stroke or transient ischemic attack (TIA) occurred during the study period. Of these, 432 met the inclusion criteria and were thus included in the analyses.

A total of 92 patients had an MRI within 12 hours of their arrival and were in the early MRI group. The remaining 340 patients had MRI performed >12 hours between admission and MRI acquisition and served as the late MRI group. The 2 groups were compared for demographic variables, comorbidities, hospital stay-related variables (day of week, time of day), and stroke severity measures including the national institutes of health (NIH) stroke scale (range 0-42)[11] Modified Rankin scores (range 0-6).[12] These comparisons did not reach statistical significance (Table 1).

There was a statistically significant difference between the early and late MRI groups for LOS. Patients in late MRI group had a median stay of a day more than the early MRI group (4 days [2.6, 7.0] versus 3 days [1.8, 4.9]; $P < .001$). Decreased LOS can also be due to increased mortality. Therefore, this analysis was repeated for the 412 patients discharged alive; the LOS for the 2 groups followed a similar pattern as the full patient set (see Table 2).

Discussion

This study demonstrates that obtaining an early MRI brain (within 12 hours of admission) in patients with focal neurological deficits helps reducing the length of hospital stay. Studies from US and Canada hospitals show that the use of MRI in the workup of stroke was associated with shorter hospitalization.[13]

Acute stroke care remains a major financial burden and LOS is a major determinant of the cost incurred during hospitalization.[14] Reduced LOS decreases medical costs for both hospitals and patients. Furthermore, stroke is a major cause of disability and many stroke patients are transitioned to rehabilitation facilities after hospital discharge.[14] Early acquisition of a brain MRI allows for faster transition of the patient from the inpatient hospital setting to home or rehabilitation facilities for faster initiation of therapy. This in turn has been shown to provide a better chance of recovery.[15]

The reason we saw early discharge/decreased LOS in stroke patients who get early MRI is multifactorial. First and foremost, MRI helps rule out stroke mimics and aids the clinician toward the appropriate workup for stroke mimics. Early initiation of this workup assists in early diagnosis, management, and discharge planning. Second, MRI is an important tool that assists in the determination of stroke etiology with appropriate follow-up investigations and treatment.[16] In clinical practice, cases of a nondiagnostic head CT or unclear stroke localization pose a diagnostic challenge. For example, small watershed infarcts may not be appreciated on head CT, but can be seen on MRI and direct the neurologist to evaluate for intracranial or extracranial vessel stenosis, vasculitis or vasculopathy, which would change management. On the other hand, a small subcortical stroke may point toward workup and

Table 1. *Patient demographics/baseline characteristics*

	Arrival to MRI ≤12 hours (N = 92)	Arrival to MRI > 12 hours (N = 340)	*P*
Characteristic			
Age (mean ± SEM)	68.3 ± 1.5	70.4 ± .7	.249
Gender—Male (%)	51 (55.4)	163 (47.9)	.202
Ethnicity: White (%)	63 (68.5)	241 (70.9)	.710
Black (%)	10 (10.9)	45 (13.2)	
Latino (%)	12 (13.0)	33 (9.7)	
Other (%)	7 &.6)	21 (6.2)	
Comorbidities (%): Hypertension	79 (85.9)	280 (82.4)	.425
Diabetes	25 (27.2)	110 (32.4)	.342
Heart disease	26 (28.3)	114 (33.5)	.338
CHF	11 (12.0)	57 (16.8)	.261
High cholesterol	63 (68.5)	220 (64.7)	.499
Atrial fibrillation	24 (26.1)	82 (24.1)	.697
Atherosclerosis	21 (30.0)	101 (38.8)	.174
Depression/Anxiety	16 (17.4)	69 (20.3)	.534
Dementia	12 (13.0)	40 (11.8)	.738
Smoking	21 (23.1)	64 (18.9)	.379
Alcohol	7 (7.7)	36 (10.7)	.404
Drug abuse	3 (3.3)	15 (4.5)	.775
Living Situation (%):	16 (17.8)	74 (22.1)	.374
Living independently Living in facility	8 (8.9)	29 (8.7)	.945
Type of event (%)—ischemic stroke versus TIA	79 (85.9)	288 (84.7)	.782
Weekend arrival (%)	24 (26.1)	102 (30.0)	.464
Shift arrival (%): Day	40 (43.5)	157 (46.2)	.170
Evening	32 (34.8)	136 (40.0)	
Overnight	20 (21.7)	47 (13.8)	
Severity of Stroke: Baseline mRS Median (IQR)	0 (0, 2)	0 (0, 2)	.621
NIHSS at admission, Median (IQR)	4 (2, 9.5)	4.5 (2, 11.2)	.544

Table 2. *Length of stay and other outcomes*

	Arrival to MRI ≤12 hours	Arrival to MRI > 12 hours	*P*
Outcomes			
Median length of Stay in days (IQR)	3 (1.8, 4.9)	4 (2.6, 7.0)	.001*
Median length of Stay with mortality excluded (IQR)	3 (1.8, 4.8)	3.8 (2.6, 7.0)	.003*
Mortality (%)	3 (3.3)	17 (5.0)	.588
Discharged home (%)	39 (4.4)	132 (38.8	.535
Severity of Stroke (d/c alive): Hospital mRS in median (IQR)	3.5 (1, 4)	4 (1, 4)	.342
NIHSS at discharge in median(IQR)	2 (0, 6)	2 (1, 5)	.876

*Statistically significant difference in median length of stay in early versus late MRI group, even after exclusion of mortality.

management of small vessel disease risk factor control and management. MRI lesion localization and the association with stroke etiology has been investigated in many studies, with some finding good and others finding poor correlation.[16-24] Current 2018 AHA guidelines acknowledge that the use of MRI DWI sequences may be helpful in the workup of patients with unclear stroke localization by guiding treatments, such as carotid revascularization.[6]

An underappreciated value of early MRI in stroke is its educational importance at academic institutions. For the most part, comprehensive stroke centers are academic medical centers which train neurology residents and stroke fellows. Most residency programs have educational conferences, such as morning report,[25,26] where new admissions along with the imaging studies are discussed. In our experience, availability of an early MRI in patients presenting with a stroke syndrome is an invaluable educational resource to confirm or rule out the diagnosis of stroke and correlate the suspected stroke etiology and localization with the MR-DWI findings, which assists

with planning the appropriate treatment strategy in a timely fashion.

Recent AHA guidelines suggest that routine use of MRI for initial stroke diagnosis and planning of subsequent treatment is not cost effective and its effect on stroke outcome is uncertain.[6] This is primarily based on data from decision analytic modeling and systematic reviews with meta-analysis. These recommendations have been made due to paucity of research studies proving the cost-effectiveness of MRI. Although, our study is a retrospective data analysis from one comprehensive stroke center, it does provide evidence and paves the road for future prospective studies on the cost effectiveness of MRI in acute ischemic stroke management.

One important limitation of our study was that it was not designed to look at seasonal variation in stroke admission rates. Although our hospital is a tertiary stroke care center and the stroke unit is at full capacity most time of the year, this can be a potential confounding factor as patients who get admitted during busier times tend to wait longer for MRI. Future studies looking at seasonal variation in admission rates and its effect on MRI times and hospital LOS are needed.

In summary, MRI performed within 12 hours of hospital admission has the potential to improve diagnostic accuracy, clinical correlation, and patient management and ultimately help in decreasing LOS, which makes it a cost effective diagnostic study. Our study design does not establish cause and effect but clearly suggests that early imaging could expedite inpatient care and discharge in stroke patients. Future studies are needed to determine if early performance of diagnostic studies like MRI has an impact on functional recovery in stroke patients, due to early discharge to rehabilitation facilities.

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