Streamlined Hyperacute Magnetic Resonance Imaging Protocol Identifies Tissue-Type Plasminogen Activator–Eligible Stroke Patients When Clinical Impression Is Stroke Mimic

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Background and Purpose—Stroke mimics (SM) challenge the initial assessment of patients presenting with possible acute ischemic stroke (AIS). When SM is considered likely, intravenous tissue-type plasminogen activator (tPA) may be withheld, risking an opportunity to treat AIS. Although computed tomography is routinely used for tPA decision making, magnetic resonance imaging (MRI) may diagnose AIS when SM is favored but not certain. We hypothesized that a hyperacute MRI (hMRI) protocol would identify tPA-eligible AIS patients among those initially favored to have SM.

Methods—A streamlined hMRI protocol was designed based on barriers to rapid patient transport, MRI acquisition, and post-MRI tPA delivery. Neurologists were trained to order hMRI when SM was favored and tPA was being withheld. The use of hMRI for tPA decision making, door-to-needle times, and outcomes were compared before hMRI implementation (pre-hMRI: August 1, 2011 to July 31, 2013) and after (post-hMRI, August 1, 2013, to January 15, 2015).

Results—Post hMRI, 57 patients with suspected SM underwent hMRI (median MRI-order-to-start time, 29 minutes), of whom, 11 (19%) were diagnosed with AIS and 7 (12%) received tPA. Pre-hMRI, no tPA-treated patients were screened with hMRI. Post hMRI, 7 of 106 (6.6%) tPA-treated patients underwent hMRI to aid in decision making because of suspected SM (0% versus 6.6%; P=0.001). To ensure standard care was maintained after implementing the hMRI protocol, pre-versus post-hMRI tPA-treated cohorts were compared and did not differ: door-to-needle time (39 versus 37 minutes; P=0.63), symptomatic hemorrhage rate (4.5% versus 1.9%; P=0.32), and favorable discharge location (85% versus 89%; P=0.37).

Conclusions—A streamlined hMRI protocol permitted tPA administration to a small, but significant, subset of AIS patients initially considered to have SM. (Stroke. 2016;47:1012-1017. DOI: 10.1161/STROKEAHA.115.011913.)

Key Words: magnetic resonance imaging ■ stroke ■ thrombolytic therapy ■ tissue-type plasminogen activator

Rapid thrombolysis improves clinical outcomes in acute ischemic stroke.1–3 Although the diagnostic accuracy of magnetic resonance imaging (MRI) for ischemic stroke is far superior to computed tomography (CT),4,5 it is unknown whether hyperacute MRI (hMRI) improves clinical outcomes or accuracy of intravenous tissue-type plasminogen activator (tPA) decision making.6 Beyond longer scanning times than CT, several practical challenges of hMRI include access to MRI at all hours, physical location of MRI outside the emergency department, safety contraindications, and access to rapid MRI interpretation. Therefore, using hMRI instead of noncontrast CT as a general screening tool for thrombolytic decision making should be approached cautiously because of its potential to delay treatment until improved outcomes can be demonstrated.7

Although hMRI may be impractical for all patients presenting with possible stroke, we hypothesized that hMRI may benefit a subset of stroke patients who are deprived of thrombolytic therapy because of an initial diagnosis of stroke mimic. Stroke mimics commonly challenge the initial clinical
assessment of patients presenting with possible stroke.\textsuperscript{6–11} In such cases, CT is inadequate to exclude ischemic stroke because it is typically normal in the first few hours after symptom onset.\textsuperscript{5,5} When stroke mimic is considered likely, intravenous tPA may be withheld, risking an opportunity to treat an acute ischemic stroke.

Before 2013, hMRI for acute ischemic stroke was rarely used at our institution because of process delays that would prevent intravenous tPA administration within the treatment window. We have previously applied lean manufacturing principles and value stream analysis (VSA; a lean method developed by companies to improve speed and quality in industrial processes) to successfully reduce our door-to-needle times for ischemic stroke patients eligible for intravenous tPA.\textsuperscript{12} In 2013, we utilized a similar lean process to create a streamlined hMRI protocol. We hypothesized that the streamlined hMRI protocol would identify a small, but important group of intravenous tPA-eligible patients among those initially favored to have stroke mimic.

Methods

VSA for Streamlined hMRI Protocol

In April 2013, a 2-day multidisciplinary meeting in the form of a VSA was held, comprised the following individuals: neurology, radiology, and emergency medicine physicians, radiology technologists and managers, emergency medicine nurses, an emergency medicine pharmacist, and a process engineer. The goal of this team event was to apply active stream mapping techniques to understand current MRI process, identify barriers, and plan appropriate process improvements, enabling rapid hMRI without compromising safety. The team set a goal door-to-MRI time of <45 minutes. The current state map revealed numerous barriers to patient flow including delays caused by inefficient MRI ordering and safety screening, patient and staff preparation for MRI (demetal), patient transport, MRI acquisition, MRI interpretation, and post-MRI tPA delivery. A planned future state was mapped, which included target metrics for door-to-MRI and door-to-needle times for each segment of the process (Figures I and II in the online-only Data Supplement).

Major sources of delay and their respective solutions were identified: (1) a scanning prioritization list for MRI technicians was created allowing hMRI to signify highest priority with the exception of ICU or anesthetized patients who were already being scanned; (2) the MRI screening sheet was streamlined and placed near trauma bays where the acute stroke patients were evaluated; (3) MRI-compatible cardiac leads and patient gowns without snaps were purchased and placed near treatment rooms; (4) the hMRI imaging protocol was condensed to <6 minutes (Table 1); and (5) a Pyxis Medstation was placed in MRI and stocked with tPA and antihypertensive medications. The final step before implementing the streamlined hMRI protocol was providing training to all team members. The hMRI protocol went live August 1, 2013, ∼4 months after the 2-day VSA was held.

Decision Making for hMRI

Treating neurologists were trained to order hMRI when the initial diagnostic impression was likely stroke mimic, but when ischemic stroke could not be entirely ruled out and when the patient was otherwise tPA eligible. Neurologists were specifically instructed to ask themselves whether they would give the patient tPA if MRI was not available at their institution: if yes, they were instructed to proceed with tPA administration without hMRI; if no, they were instructed to proceed with hMRI to aid treatment decision making (Figure 1). This instruction was important to avoid overutilization of hMRI, which could inappropriately delay tPA treatment in patients for whom hMRI would be unlikely to alter decision making. We hypothesized that our stroke mimic rate should not change significantly after initiating this protocol if neurologists were only proceeding to hMRI for patients they would not have treated with intravenous tPA under the previous protocol.

Data Analysis

Before and after the streamlined hMRI protocol was implemented, we prospectively collected baseline characteristics, discharge location, protocol metrics such as tPA administration time and door-to-needle time, according to the routine quality and safety monitoring practices at our institution for all tPA-treated patients. Additional outcomes including discharge diagnosis and symptomatic intracerebral hemorrhage (defined as any clinically identified neurological worsening within 36 hours of stroke onset associated with acute blood on brain imaging)\textsuperscript{13} were obtained by chart review. After hMRI protocol implementation in August 2013, we collected baseline characteristics and protocol metrics for all non-tPA-treated patients going to hMRI. The use of hMRI before hMRI protocol implementation was only tracked in tPA-treated patients, and therefore its utilization or baseline characteristics in non-tPA-treated patients going to hMRI were not collected. To ensure that the new protocol was not affecting standard of care tPA administration in patients more likely to have ischemic stroke on initial evaluation, we compared overall door-to-needle times and outcomes for all patients receiving tPA regardless of hMRI use, before (August 1, 2011 to July 31, 2013) and after (August 1, 2013 to January 15, 2015) protocol implementation. Student’s t test (parametric) and Mann–Whitney U test (nonparametric) were used for analysis of continuous variables. Fisher exact test was used for analysis of binary outcome variables. \( P<0.05 \) was required for significance. SPSS version 22 was used for all statistical analyses.

Results

Patient Characteristics and Protocol Metrics Post hMRI

In the pre-hMRI epoch, hMRI was rarely used because an adequately rapid hMRI protocol was not available. Therefore, no tPA-treated patients were screened with hMRI before tPA delivery. In the post-hMRI epoch, 57 patients underwent hMRI for evaluation of suspected stroke mimic and to rule out ischemic stroke. Age was 55±14 years, 39 (68\%) were women, and median National Institutes of Health Stroke Scale (NIHSS) was 4 (2–10). Median time of hMRI order to hMRI delivery was 29 (17–45) minutes and median time of patient arrival to hMRI began was 61 (52–94) minutes (Table 2).

Of the 57 patients, 11 (19\%) and 4 (9\%) were discharged with diagnoses of acute ischemic stroke and transient ischemic attack, respectively. Remaining discharge diagnoses included

<table>
<thead>
<tr>
<th>Table 1. Streamlined Hyperacute Magnetic Resonance Imaging Protocol</th>
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<tbody>
<tr>
<td><strong>Sequence</strong></td>
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<tr>
<td>Localizer</td>
</tr>
<tr>
<td>DWI/ADC</td>
</tr>
<tr>
<td>FLAIR</td>
</tr>
<tr>
<td>T2* GRE</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td><strong>Optional sequences</strong></td>
</tr>
<tr>
<td>Time-of-flight MRA</td>
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<tr>
<td>Perfusion-weighted imaging</td>
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</tbody>
</table>

ADC indicates apparent diffusion coefficient; DWI, diffusion-weighted imaging; FLAIR, fluid-attenuated inversion recovery; GRE, gradient echo; and MRA, magnetic resonance angiography.
conversion disorder in 14 (25%), seizures in 11 (19%), complicated migraine in 6 (11%), and other in 11 (19%) including diagnoses of encephalitis, peripheral neuropathy, syncope, and stroke recrudescence. In 5 of the 11 patients who were diagnosed with seizures, hMRI demonstrated findings supportive of seizures including gyriform diffusion restriction across vascular territories or an underlying structural lesion. In the remaining nonstroke causes, MRIs did not yield additional diagnostic information beyond being negative for stroke or other acute pathology. Because of the hyperacute nature of these scans, contrast was administered in a minority of patients.

Intravenous tPA-Treated Patients
Pre and Post hMRI
To confirm that implementation of a streamlined hMRI protocol changed patient management, hMRI utilization was compared pre- and post-hMRI in tPA-treated patients. In the pre-hMRI epoch, 159 patients (=6.6 patients/mo) received intravenous tPA, of whom, none underwent hMRI before treatment. In the post-hMRI epoch, 106 patients (=6.6 patients/mo) received intravenous tPA, of whom 7 (6.6%) patients underwent hMRI before intravenous tPA (0% versus 6.6%; P=0.001; Table 3). This increase in tPA treatments screened with hMRI in the post-hMRI epoch was not unexpected as hMRI was rarely used before its implementation. Four of the 11 patients with acute ischemic stroke on MRI did not receive tPA despite the MRI diffusion-weighted imaging positivity because of elevation of blood pressure, the presence of a subacute appearing stroke/change in last known normal time, and 2 patients with rapidly improving stroke/minor deficits. Clinical histories and diffusion-weighted imaging of the 7 patients who received intravenous tPA are shown (Figure 2) demonstrating (1) clinical histories that were consistent with possible stroke mimics, suggesting appropriate utilization of hMRI and use of the decision algorithm in the Methods section of this article and Figure 1, (2) the relatively small size of the stroke lesions and, in some, lesion locations known to cause nonfocal deficits (ie, thalamus causing cognitive changes), and (3) diffusion-weighted imaging–positive lesions were only subtly hyperintense caused by the hyperacute timing of imaging, whereas hypointensity on ADC was more useful for diagnosis.

To ensure that hMRI protocol implementation did not adversely affect the standard care for the majority of tPA-treated patients screened with CT alone, we evaluated

Table 2. Baseline Characteristics, MRI Positivity, and Discharge Diagnoses in Suspected Stroke Mimics Taken to hMRI After Initiation of Streamlined Protocol*
Table 3. Comparison of Baseline Variables, Protocol Metrics, and Safety Outcomes Pre- and Post-hMRI for All tPA-Treated Patients (Left) and Comparison of Post-hMRI tPA-Treated Patients Screened With CT Alone vs CT and hMRI (Right)

<table>
<thead>
<tr>
<th></th>
<th>Pre-hMRI August 2011 to July 2013 (n=159)</th>
<th>Post-hMRI August 2013 to January 2015 (n=106)</th>
<th>P Value</th>
<th>Post-hMRI (August 2013 to January 2015; n=106)</th>
<th>Screened With CT Alone (n=99)</th>
<th>Screened With CT and hMRI (n=7)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>62 (54–75)</td>
<td>67 (56–75)</td>
<td>0.10</td>
<td>66 (56–75)</td>
<td>72 (64–76)</td>
<td>0.41</td>
<td></td>
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<tr>
<td>Sex, women</td>
<td>78 (49%)</td>
<td>55 (52%)</td>
<td>0.71</td>
<td>49 (50%)</td>
<td>6 (86%)</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Race, black</td>
<td>90 (57%)</td>
<td>55 (52%)</td>
<td>0.45</td>
<td>50 (50%)</td>
<td>5 (71%)</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>Baseline NIHSS</td>
<td>7 (4–12)</td>
<td>8 (4–15)</td>
<td>0.23</td>
<td>8 (4–14)</td>
<td>4 (2–12)</td>
<td>0.22</td>
<td></td>
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<tr>
<td>Screened with hMRI before tPA</td>
<td>0 (0%)*</td>
<td>7 (7%)*</td>
<td>0.001*</td>
<td>0 (0%)</td>
<td>7 (100%)</td>
<td>...</td>
<td></td>
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<tr>
<td>Door-to-needle time, min</td>
<td>39 (28–58)</td>
<td>37 (25–66)</td>
<td>0.63</td>
<td>37 (28–52)*</td>
<td>112 (100–116)*</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
<tr>
<td>Onset-to-needle time, min</td>
<td>116 (85–155)</td>
<td>130 (84–172)</td>
<td>0.81</td>
<td>102 (70–159)</td>
<td>143 (133–180)</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Favorable discharge location†</td>
<td>132 (85%)</td>
<td>94 (89%)</td>
<td>0.37</td>
<td>88 (89%)</td>
<td>6 (85%)</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>Symptomatic ICH‡</td>
<td>7 (4.5%)</td>
<td>2 (1.9%)</td>
<td>0.32</td>
<td>2 (2%)</td>
<td>0 (0%)</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Stroke mimic§</td>
<td>21 (13.2%)</td>
<td>12 (11.3%)</td>
<td>0.71</td>
<td>12 (12%)</td>
<td>0 (0%)</td>
<td>1.0</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Screened With CT Alone (n=99)</th>
<th>Screened With CT and hMRI (n=7)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>66 (56–75)</td>
<td>72 (64–76)</td>
<td>0.41</td>
</tr>
<tr>
<td>Sex, women</td>
<td>49 (50%)</td>
<td>6 (86%)</td>
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<td>50 (50%)</td>
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</tr>
<tr>
<td>Baseline NIHSS</td>
<td>8 (4–14)</td>
<td>4 (2–12)</td>
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<td>Door-to-needle time, min</td>
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<td>112 (100–116)</td>
<td>&lt;0.001*</td>
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<tr>
<td>Onset-to-needle time, min</td>
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</tr>
<tr>
<td>Stroke mimic§</td>
<td>12 (12%)</td>
<td>0 (0%)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*P<0.05 required for significance.
†Defined as discharge to home or inpatient rehab.
‡Defined as any clinically identified neurological worsening <36 hours of onset associated with blood on head CT.13
§Defined as any discharge diagnosis other than stroke.

Protocol metrics and clinical and safety outcomes pre- and post-hMRI for all tPA-treated patients. There were no differences in door-to-needle or onset-to-needle times pre- and post-hMRI (Table 3). Furthermore, there were no statistically significant differences in favorable discharge location, symptomatic intracerebral hemorrhage rate, or stroke mimic rates between the 2 epochs.

The 7 patients who received intravenous tPA after hMRI had subsequent outcomes and discharge locations similar to our other patients receiving intravenous thrombolysis without MRI, and none had hemorrhagic conversion. The median door-to-MRI begin and door-to-needle times were 55 (49–67) and 112 (100–116) minutes, respectively, for the 7 patients treated with intravenous thrombolysis.

Patient Characteristics and Protocol Metrics for Intravenous tPA-Treated Patients Screened by hMRI Compared With Those Screened by CT Alone

To evaluate the impact of hMRI on protocol metrics and potential for adding delays to tPA treatment, door-to-needle and onset-to-needle times were compared. For the 99 tPA-treated patients screened with CT alone, door-to-needle times were much shorter than for the 7 patients screened with CT and sent to hMRI before intravenous tPA (37 [28–52] versus 112 [100–116] minutes; P<0.001). Furthermore, there was a trend toward longer onset-to-needle times when utilizing hMRI before intravenous tPA (102 [70–159] versus 143 [133–180] minutes; P=0.14). Patients screened with hMRI compared to those screened with CT alone showed...
trends toward a lower NIHSS (4 [2–12] versus 8 [4–14]; P=0.22) and were more likely women (86% versus 50%; P=0.11), which are characteristics that have been associated with stroke mimics in other studies. Clinical outcome measures, symptomatic hemorrhage rates, and stroke mimic rates did not differ between those screened with hMRI versus CT alone (Table 3).

**Discussion**

Our results demonstrate that hMRI identifies ischemic stroke in a subset of patients initially thought to have stroke mimic, and further that it can be performed sufficiently quickly to enable treatment with intravenous thrombolysis when appropriate. Given these findings of 7 treatable patients, we suspect that there were AIS patients in the pre-hMRI epoch who were not offered tPA treatment because of being initially diagnosed as stroke mimics. It is possible that this AIS patient subgroup is being overlooked for tPA treatment at many centers. An acute ischemic stroke was only found in a minority of the 57 patients evaluated with hMRI, in accordance with our instructions to only include patients who would not normally receive intravenous tPA if hMRI were not available. At our high-volume stroke center, several patients received improved care over a 16-month period directly as a result of implementing hMRI. Also, we could not detect any evidence that hMRI worsened care of patients with initial clinical suspicion for stroke who did not undergo hMRI.

The door-to-needle times for the 7 patients treated with intravenous tPA were considerably longer than for patients clinically suspected to have an acute stroke initially and who did not undergo hMRI, thus reinforcing cautious use of hMRI in suspected stroke patients at an institution such as ours where MRI is physically distant from the ED and hMRI is performed in a minority of patients. However, the lengthy door-to-needle times are permissible when compared with not receiving intravenous tPA at all, as would have been the case before implementation of the hMRI protocol. The long door-to-MRI begin and MRI-to-needle times suggest that improvements can be made. We used a value stream-based analysis to create the hyperacute stroke MRI protocol at an institution where the MRI scanner is separated from the emergency department by several floors and hallways. Applying a similar analysis to improve the hMRI protocol may help reduce treatment times. Shah et al recently reported the use of lean improvement methods to improve door-to-needle times using a hMRI protocol in the vast majority of patients. Over 2 years, door-to-needle times were reduced from median of 93 to 55 minutes.

Although our study was not designed to assess cost-effectiveness, we note that 1 in 8 patients were screened with hMRI to be treated with intravenous tPA, raising the question of whether this protocol is sufficiently cost-effective to warrant its use more universally, particularly in low-volume stroke centers. Furthermore, stroke lesion size in suspected stroke mimics who had ischemic stroke on MRI tended to be smaller with lower NIHSS scores, for which net benefit of tPA may be debated. Recent analysis of combined randomized clinical trial data testing the efficacy of intravenous tPA demonstrates significant benefit of intravenous tPA in patients with low NIHSS scores (0–4). The value of hyperacute stroke MRI may extend beyond the opportunity to treat with intravenous tPA in that it may result in more rapid diagnosis, ie, stroke or otherwise, and thereby reduce length of stay although this was not evaluated in the current study.

Our data demonstrate that stroke mimic rates in tPA-treated patients were unchanged comparing rates before and after implementation of the hMRI protocol. If our hMRI protocol had been utilized in the majority of tPA-treated patients, we would have expected our stroke mimic rate to decrease after implementing the hMRI protocol. However, as we only utilized hMRI for a minority of subjects, our stroke mimic rate was statistically unchanged. The potential benefit of the streamlined hMRI protocol favored inclusion of more patients for intravenous tPA, rather than reducing potential harm of tPA by reducing the rate of tPA treatment in stroke mimics. If hMRI protocols could truly be streamlined and offered to a majority of patients as has been successful at select centers, tPA treatment within stroke mimics could be greatly reduced, which may be cost-effective given the cost of tPA and inpatient monitoring required for 24 hours post tPA administration.

There are several limitations to this study. This was not a randomized trial and differences between cohorts separated in time could be because of a variety of factors including differences in treatment protocols. Although the majority of data were collected prospectively, analysis was retrospective and unblinded. The sample size is small and limited to a single institution. Although treating neurologists were trained to follow a decision-algorithm when considering hMRI, we did not track actual use of this algorithm, and therefore it is possible that patients were taken to hMRI who would have otherwise been given intravenous tPA had they not had access to MRI. Given the clinical histories, low NIHSS, and minority of strokes in the hMRI group, it seems likely that the neurologists did reserve hMRI for suspected mimics who were otherwise tPA eligible with a goal of ruling-out ischemic stroke. Furthermore, diffusion-weighted imaging is falsely negative in 5% to 10% of cases, especially early after symptom onset, raising the possibility that hMRI failed to identify additional stroke patients among the cohort of 57 patients reported here.

**Conclusions**

A hyperacute MRI stroke protocol, designed by multidisciplinary VSA, was effective in identifying a small subset of stroke patients eligible for intravenous tPA who were initially suspected to have a stroke mimic. Door-to-needle times were long in those patients treated with intravenous tPA caused by hMRI, suggesting that ongoing process improvements are required to enhance the effectiveness of hMRI.

**Acknowledgments**

We acknowledge the Washington University neurology and emergency medicine residents, Barnes-Jewish Hospital ED nurses, radiology, and patient care technicians.
Sources of Funding
This study was supported by grants from National Institute of Health K23 NS069807 (to Dr Ford) and National Institutes of Health CTSA UL1 TR000448 from the Washington University Institute of Clinical and Translational Sciences.

Disclosures
Dr Heitsch, MD: speakers’ bureau: entity: Genentech; relationship: myself; explanation: speaker’s bureau; compensation: significant (>10K or 5%); consultant or advisory board: entity: Genentech; relationship: myself; explanation: advisory board; compensation: modest (<10K or 5%). Dr Panagos, MD: honoraria: entity: Genentech; relationship: myself; explanation: speakers bureau; compensation: significant (>10K or 5%). Dr Benzinger, MD, PhD: other research support: yes, I have a other research support to disclose. Entity: National Institutes of Health (NIH); relationship: myself; explanation: research grants compensation: no compensation; entity: Avid/Lilly; relationship: myself; explanation: research grants; compensation: no compensation; entity: Roche, Lilly, Avid; relationship: myself; explanation: Clinical Trials; compensation: no compensation; Entity: DOD; relationship: myself; explanation: grant review; compensation: modest (<10K or <5%); entity: National MS Society; relationship: myself; explanation: grant review; compensation: no compensation; entity: Foundation for the NIH; relationship: myself; explanation: research grant; compensation: no compensation. Dr Ford, MD, MSc: research grant: entity: NIH National Institute of Neurological Disorders and Stroke; relationship: myself; explanation: 5K23NS069807-05; compensation: significant (>10K or 5%). The other authors report no conflicts.

References
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Stroke. 2016;47:1012-1017; originally published online February 18, 2016;
doi: 10.1161/STROKEAHA.115.011913

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http://stroke.ahajournals.org/content/47/4/1012

Data Supplement (unedited) at:
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SUPPLEMENTAL MATERIAL

A streamlined hyperacute MRI protocol identifies tPA-eligible stroke patients when clinical impression is stroke mimic

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Supplemental Figure I

The end result of the two day Value Stream Analysis mapped a planned “future state” for the hyperacute MRI protocol beginning from patient arrival to IV tPA delivery in the MRI suite. Target metrics for door-to- MRI and door-to-needle times while using hyperacute MRI for clinical decision-making were included.
EMS Transportation
(typically patient arrives 5-15 min after EMS call)

EMS work-up

Phone

ED Comm. Center takes EMS call, sends stroke page

Stroke Team goes to ED (TCC Bay or CT room)

Patient arrival

Move to CT (in ED)

CT scan in ED

Move to TCC

Neurology Resident discussion with Chief

MRI decision

Laboratory

3 tubes

5-8 min.

0.5 min.

Nurse Work-up

15 min.

20 min.

Map shows EMS transport

Increasing pre-arrival

- 75% EMS transport
- 20% walk-in to ED
- 5% in house
Supplemental Figure II

After the two day VSA, several small group meetings were held in the form of rapid improvement events (RIE) over several weeks to implement solutions. The standard work for each role (RN, neurology, emergency medicine and radiology MDs, and MR technician) within each of the four phases was defined in detail: (1) **Code Stroke in ED** – this phase included the time from patient arrival until the decision to go to hMRI was made; (2) **hMRI Process in ED** – this phase included all standard work for patient and staff preparation for hMRI and transport to hMRI, (3) **hMRI Process in MRI** – this phase included safe patient transfer into the scanner room, scan completion, and radiology image review, and (4) **tPA Delivery in MRI** – this phase included repeat neurological evaluation and blood pressure to ensure patient remained an IV tPA candidate, preparation and delivery of tPA in the MRI suite. The standard work for each role (RN, neurology, emergency medicine and radiology MDs, and MR technician) within each of the four phases was defined in detail.
# Hyperacute MRI Protocol

**Team Process:** Code Stroke Process in Emergency Department

Document Owners & Approvers: ED Manager & Neurology Resident Program Director

## Patient arrival
- **Move Patient to CT room**

## CT Scan
- **Move Patient to TCC room**
- **ED Exam / Workup**
- **Medical Team Decision**
  - **Medical Decision**

### Neurology Resident (Stroke)
- Begin Exam
- History/NIHSS
- Observe live CT image
- Place patient on stretcher, move to TCC room
- Complete exam, History/NIHSS
- Discuss treatment plan with ED Attending (call Stroke Fellow / attending as needed)

### ED Nurse
- Move patient to CT room
- Put Pt in HMED & order CT
- Move patient to CT table
- Protocol all stroke orders & HPI

### ED PCT
- Move patient to table
- Run CT scan
- Place patient on stretcher
- Draw labs
- Place Bilateral IVs
- Watch Physical Exam
- Discuss treatment plan with Neurology Resident
- Make treatment decision

### CT Technologist
- Move pat. to table
- Run CT scan
- Place patient on stretcher
- Process Image

### ED Physician
- Go to CT
- Perform Physical Exam
- Order CTA and extra labs (as needed)

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**1 min.**

**5-8 min.**

**1 min.**

**5-10 min.**

**2-10 min.**

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Note: This work is time sensitive and should be performed as quickly and safely as possible. The times above are expected flow times.
### Hyperacute MRI Protocol

**Team Process:** Hyper Acute MRI Process in Emergency Department

**Document Owners & Approvers:** ED Manager, MRI Supervisor & Neurology Resident Program Director

<table>
<thead>
<tr>
<th>Decision for MRI</th>
<th>Prepare for MRI: Nurse Handoff, MRI order &amp; screening sheet, travel logistics, etc.</th>
<th>Move patient to 5th floor MRI</th>
<th>Arrive in MRI</th>
</tr>
</thead>
</table>
| **Neurology Resident (Stroke)** | 1) Request orders from ED MD (MRI, BP meds, bed placement)  
2) Tell Nurse to prepare for MRI  
3) Complete MRI Screening Sheet, write Creatinine & patient weight on Screening Sheet before faxing *  
4) Fax Screening sheet to MRI (keep copy)  
5) Call MRI Charge Tech 362-1676 (give ETA if possible)  
6) Ensure patient is in MRI gown (laces only, no metal snaps) | • Get 2 Patient Belonging Bags (for MD/RN items)  
• Transport patient to MRI  
• Place metal items in bag while on elevator |  |
| **ED Nurse** | 1) Call Charge, Sign-out patients to assigned ED nurse  
*Note: do not print charts, HMED is available in MRI*  
2) Hook up Transport Monitor  
3) Obtain ED Med Bag from Pyxis | • Transport patient to MRI  
- Notify Comm Center on way out  
• Place metallic items in bag while on elevator |  |
| **ED Physician** | • Enter order for MRI  
• Enter open order for BP meds  
• Enter order for bed placement (don’t “up arrow”) |  |  |
| **MRI Charge Tech** | 1) Receive call from Neurology Resident  
2) Review order and screening sheet, Calculate GFR from Creatinine on screening sheet  
3) Call Advanced Imaging Radiologist to notify Hyper Acute process underway *(if day (8AM-10PM) call once you receive the hyper acute screening sheet so fellow can come to scanner; if night, call when MRI begins so fellow can read from ClinDesk)*  
4) Remove patient from 3T scanner (if needed), notify Tech of hyper-acute patient on the way  
5) Prepare Invivo monitor, MRI stretcher and ready Zone 2 |  |  |
| **Advanced Imaging Radiologist** | • Receive call from MRI Charge Tech  
• Go to MRI to for "live" read and assist treatment decision *(If night, read image on ClinDesk and discuss over phone with Neurology Resident)* |  |  |

*NOTE: If patient (or family) cannot answer MRI screening questions, obtain a “shunt series” plain film X-ray in the ED prior to sending the patient to MRI. Call the Advanced Imaging Fellow to notify as soon as X-ray is complete. You may transport patient to MRI while AI Fellow determines if patient is MRI eligible based on X-ray.*

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6-15 min.  
3-4 min.
### Hyperacute MRI Protocol

**Team Process:** Hyper Acute MRI Process in MRI Department

**Document Owners & Approvers:** ED Manager, MRI Supervisor & Neurology Resident Program Director

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<table>
<thead>
<tr>
<th>MRI Charge Tech</th>
<th>MRI Technologist</th>
<th>ED Nurse</th>
<th>Neurology Resident (Stroke)</th>
<th>Advanced Imaging Radiologist</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Facilitate MRI Safety Screening</td>
<td>• Prepare MRI room and coil</td>
<td>• Place bag with metal objects in locker</td>
<td>• Place bag with metal objects in locker; place White Coat on coat hook</td>
<td></td>
</tr>
<tr>
<td>• Facilitate MRI Safety Screening</td>
<td>• Setup MRI</td>
<td>• Transfer to MRI stretcher</td>
<td>• Transfer to MRI stretcher</td>
<td></td>
</tr>
<tr>
<td>• Move to Zone 4</td>
<td>• Run MRI</td>
<td>• Place patient to Zone 4</td>
<td>• Move patient to Zone 4</td>
<td></td>
</tr>
<tr>
<td>• If night hours, call AI Fellow on control room speaker phone</td>
<td>• Push images to ClinDesk asap</td>
<td>• Monitor Patient</td>
<td>• Discuss plan, include Stroke Attending/Fellow as needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Call ED Attending (758-6903) on speaker phone, with ED nurse listening</td>
<td></td>
</tr>
</tbody>
</table>

### Step-by-Step Process:

1. **Arrive in MRI**
2. **MRI Safety Check, Zone 2**
3. **Transfer patient to MRI safe equip.**
4. **Move to Zone 4, prepare for MRI**
5. **MRI scan, Review image**
6. **Make treatment decision with ED Attending**
7. **Medical Decision**

**Note:** If Hyper Acute MRI process occurs at night and another tPA Page occurs, the On-Call Chief Resident will call the On-Call Stroke Neurology Resident to go to MRI. The On-Call Stroke Resident will cover the Hyper-Acute MRI patient so the Night Float Resident can respond to the other Stroke Page. The On-Call Stroke Resident will assume care for the patient and makes the treatment recommendation to ED Attending. After the MRI is complete, the On-Call Stroke Resident will inform the Night Float Resident about the results if Night Float will continue to follow the patient.

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**ML-TP-0003**

Standard Work Document: Team Process

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## Hyperacute MRI Protocol

**Team Process:** Alteplase Administration Process in MRI Department

**Document Owners & Approvers:** ED Manager, MRI Supervisor & Neurology Resident Program Director

### Medical Decision
- Remove patient from MRI scanner
- Move patient to Zone 2, Mix Alteplase
- Administer Alteplase
- Travel to ED
- Begin tPA infusion in ED
- Process complete

### Neurology Resident (Stroke)
- **Receive verbal order for tPA from ED Attending on phone**
- **Assist ED Nurse with tPA "double-check"**
- **Inform family and Chief of treatment plan as needed**
- **Recheck NIHSS to ensure patient has not improved**
- **Observe bolus push**
- **Escort patient back to ED**
- **Hand-off to ED team as needed**

### ED Nurse
- **Receive verbal order for tPA from ED Attending on phone**
- **Obtain tPA from MRI Pyxis**
- **Get printout from front desk, mix tPA in Zone 2**
- **Obtain "tPA double check " from Neurology Resident**
- **Check vitals**
- **Administer tPA Bolus, infusion to start after return to ED**
- **Escort patient back to ED**
- **Complete tPA infusion in ED**

### MRI Charge Tech
- **Remove patient from MRI table**
- **Move patient to Zone 2**
- **Detach Invivo monitor, attach ED monitor**

### MRI Technologist
- **Remove patient from MRI table**
- **Move patient to Zone 2**
- **Prepare MRI for next patient**

### ED Attending
- **Give verbal order for tPA on phone**
- **Enter order for tPA (alteplase)**
- **Finalize bed placement request**

<table>
<thead>
<tr>
<th>Step</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remove patient from MRI scanner</td>
<td>2 min.</td>
</tr>
<tr>
<td>Move patient to Zone 2, Mix Alteplase</td>
<td>5 min.</td>
</tr>
<tr>
<td>Administer Alteplase</td>
<td>4 min.</td>
</tr>
<tr>
<td>Travel to ED</td>
<td>3-4 min.</td>
</tr>
<tr>
<td>Begin tPA infusion in ED</td>
<td>3 min.</td>
</tr>
</tbody>
</table>

*Standard Work Document: Team Process*