



Feasibility of using magnetic resonance imaging as a screening tool for acute stroke thrombolysis☆



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ABSTRACT

Background: Feasibility of performing MRI first for suspected hyperacute stroke patients in real-world practice has not been fully examined. Moreover, most past studies of reducing door-to-needle time (DNT) in intravenous thrombolysis were conducted using CT. The aim of this study was to evaluate the feasibility of an MRI-first policy and examine the effects of a quality improvement (QI) process for reducing DNT using MRI.

Methods: From January 2014 to August 2015, consecutive acute stroke patients who were treated with thrombolysis were prospectively enrolled into the present study. In principle, multimodal 1.5T-MRI was performed first for patients with suspected acute stroke. A step-by-step QI process for decreasing DNT, including prenotification by the emergency medical service, limiting the MRI sequence, and introduction of a rapid examination tool, was also implemented during this period. Time metrics for thrombolysis were compared between specific time periods.

Results: A total of 73 patients (27 women; median age 74 years) were included in the present study. More than 80% of the patients were screened with MRI. More patients were managed with the MRI-first policy in the late phase ($p = 0.018$). DNT (83 min in the early phase, 68 min in the middle phase, and 54 min in the late phase, $p < 0.001$) was significantly reduced across phases. The percentage of patients with DNT < 60 min increased significantly across time periods ($p < 0.001$).

Conclusion: An MRI-first policy was feasible, and DNT was substantially reduced with a QI process. This process may be applicable to other hospitals.

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1. Introduction

Time from symptom onset to reperfusion plays a critical role in managing ischemic stroke patients [1,2]. Time from symptom onset to administering intravenous (IV) recombinant tissue-plasminogen activator (rt-PA), or “onset-to-needle time (ONT)”, is a surrogate marker in patients treated with IV rt-PA [1]. ONT consists of onset-to-door time (ODT) and door-to-needle time (DNT), and past studies showed that a quality improvement (QI) process could reduce DNT [3,4] to as little as 20 min [5].

In most past studies trying to reduce DNT, computed tomography (CT) was used as a screening tool for hyperacute ischemic stroke [6–8]. CT has some advantages, such as taking a short time and availability at any time in almost all hospitals having an emergency department (ED). However, there is controversy regarding whether the clinical

outcome was improved by reducing DNT using CT [9]. Magnetic resonance imaging (MRI)-based patient selection was reported to improve short-term outcomes in patients treated with IV rt-PA [10,11], probably because diffusion-weighted imaging (DWI) depicts the extent of the ischemic lesion well [12], and T2*-weighted imaging could detect patients prone to experiencing intracerebral hemorrhage after IV rt-PA therapy [13,14]. Moreover, MR angiography (MRA) can show the site of occlusion without contrast medium injection, and such information may be beneficial for considering subsequent intraarterial therapy [15–19]. Indeed, reports suggested that MRI-based patient selection also brought more favorable outcomes than CT-based selection in patients treated with endovascular therapy [20,21]. However, few institutions perform MRI as an initial examination for suspected acute stroke patients [22], because it is much more time-consuming than CT and is probably not always available, and the feasibility of performing MRI first for suspected acute stroke patients in real-world practice has not been examined sufficiently. The aim of the present study was to evaluate the feasibility of an MRI-first policy in a tertiary general and academic hospital and examine the effect of a step-by-step QI process for decreasing DNT using MRI as the routine screening modality.

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2. Methods

The Nippon Medical School is a major general, academic, and teaching hospital in central Tokyo. Our institution is a tertiary general hospital and treats more than 10,000 patients per year through the ED, including >600 stroke admissions annually, and CT and MRI are available at any time.

From January 2014 to August 2015, consecutive acute stroke patients who fulfilled the following criteria were prospectively enrolled into the present study: (1) arrived in the ED within 4.5 h from onset; and (2) were treated with IV rt-PA. This study was approved by the institutional ethics committee. Written informed consent for the enrollment of the present study and data collection was obtained from all patients or their next of kin.

3. Patient clinical characteristics

Clinical background characteristics, including sex, age, and time of ED arrival (with “office hours” defined as Monday to Friday, 8:30 AM through 16:00 PM) were recorded on admission. Stroke severity was assessed using the National Institutes of Health Stroke Scale (NIHSS). Time metrics related to hyperacute stroke management, such as ONT, ODT, DNT, door-to-imaging time (DIT), and imaging-to-needle time (INT) were also recorded. Concomitant intra-arterial treatment and symptomatic intracerebral hemorrhage (sICH) were documented. sICH was defined as new intracerebral hemorrhage within 36 h after IV rt-PA therapy, corresponding to an increment in the NIHSS score of ≥ 4 points. Stroke etiology was determined using the Trial of ORG 10172 in Acute Stroke Treatment (TOAST) criteria [23], and functional outcomes were classified by the modified Rankin scale (mRS) [24] at hospital discharge.

3.1. Step-by-step QI process for decreasing DNT (Table 1)

3.1.1. Phase 1: January 2014 to August 2014

From January 2014, multimodal 1.5T-MRI (Echelon Oval, Hitachi Medical Systems, Tokyo, Japan) was performed first for patients suspected of having hyperacute stroke (<4 h from onset at ED arrival) in principle; exceptions to the MRI-first policy were permitted at the attending neurologist’s discretion when patients had contraindications to MRI, the general condition of the patient was poor, or MRI was unavailable due to use for other patients. In this phase, the MRI room was located on another floor, a 5-min walking distance from the ED. Prenotification by the emergency medical service (EMS) for suspected acute stroke patients was not implemented in this phase; the ED doctor called the on-site vascular neurologists after the patient arrived in the ED. At least one vascular neurology fellow with or without one resident was always in hospital outside office hours, and stroke patients were treated on a general ward for neurological disorders.

3.1.2. Phase 2: September 2014 to February 2015

The stroke unit (SU) and new ED for patients suspected acute cardiovascular diseases were opened on September 2014, and the stroke management system was re-evaluated by a working group from neurology, emergency, radiology, and nursing. Acute stroke management system was changed to: (1) managing stroke patients in the SU; (2) MRI was performed firstly for patients suspected of having acute stroke (no strict onset-to-door time limit was set because of unknown onset of time in some patients); (3) always having at least one attending vascular neurologist and one fellow, with or without a resident, in hospital, even outside office hours; and (4) having the EMS prenotify the ED and stroke neurologist when patients had a suspected acute stroke, and activating the MRI unit before patient arrival. The MRI room was located next to the new ED; and DWI (TR/TE, 6000/65 ms; b-values, 0 and 1000 s/mm²; field of view, 24 cm; acquisition matrix, 128 × 128; and slice thickness, 4.5 mm, with a 2.5-mm intersection gap), time-of-flight MRA, fluid-attenuated inversion recovery (FLAIR, TR/TE, 10,000/120 ms; TI, 2500 ms; field of view, 24 cm; acquisition matrix, 288 × 224; and slice thickness 4.5 mm, with a 2.5-mm intersection gap), T1-weighted imaging (TR/TE 540/12 ms), T2-weighted imaging (TR/TE 4200/117.52 ms), and T2*-weighted imaging (TR/TE, 480/18 ms; field of view, 24 cm; acquisition matrix, 256 × 204; and slice thickness 4.5 mm, with a 2.5-mm intersection gap) were performed routinely in this phase.

3.1.3. Phase 3: March 2015 to August 2015

From March 2015, the stroke management system had further improved reducing DNT by: (1) limiting the sequences of routine MRI to DWI, MRA, FLAIR, and T2*-weighted imaging; (2) dissolving rt-PA in sterile water and inserting it in the syringe pump before the results of all examinations were known; (3) introducing rapid examination point-of-care tools to measure platelet count (Celltac ES, NIHON KOHDEN Corporation, Tokyo, Japan), serum glucose, creatinine (ABL800 FLEX, Radiometer, Copenhagen, Denmark), and partial thrombin time-international normalized ratio (CoaguCheck XS, Roche Diagnostics, Rotkreuz, Switzerland); and (4) holding meetings to review past cases or to familiarize multidisciplinary staff with the stroke management system through role play.

4. Statistical analyses

First, proportion of patients received MRI firstly and those with DNT < 60 min in the included patients were assessed as the feasibility of an MRI-first policy. Second, clinical characteristics including time metrics related to IV rt-PA therapy were compared among the phases. Finally, differences in time metrics between during and outside office hours were evaluated. Univariate analyses were performed using the chi-squared test, Fisher’s exact test, the Kruskal-Wallis test, or the Mann-Whitney *U* test, as appropriate. The data are presented as median values (interquartile range [IQR]) or frequencies (%). All statistical analyses were performed using PASW for Windows version 17.0 software

Table 1
Step-by-step quality improvement.

	Phase 1 January 2014–August 2014	Phase 2 September 2014–February 2015	Phase 3 March 2015–August 2015
Vascular neurologist outside office hours	1 fellow ± 1 resident	1 attending + 1 fellow ± 1 resident	1 attending + 1 fellow ± 1 resident
Emergency medical service prenotification	None	Implemented	Implemented
Hyperacute stroke management	Emergency department → General ward	Emergency department → Stroke Unit	Emergency department → Stroke Unit
MRI sequence	DWI, MRA, FLAIR, T1, T2, T2*	DWI, MRA, FLAIR, T1, T2, T2*	DWI, MRA, FLAIR, T2*
Dissolve rt-PA before examination	None	None	Implemented
Rapid point-of-care examination tool	None	None	Implemented
Multidisciplinary meeting	None	None	Held once a month

MRI indicates magnetic resonance imaging; DWI, diffusion-weighted imaging; MRA, magnetic resonance angiography; FLAIR, fluid-attenuated inversion recovery; rt-PA, recombinant tissue-plasminogen activator.

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