

Inter-Observer Agreement on Diffusion-Weighted Magnetic Resonance Imaging Interpretation for Diagnosis of Acute Ischemic Stroke Among Emergency Physicians

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SUMMARY

Objectives

Diffusion-weighted magnetic resonance imaging (DW-MRI) is a highly sensitive tool for the detection of early ischemic stroke and is excellent at detecting small and early infarcts. Nevertheless, conflict may arise and judgments may differ among different interpreters. Inter-observer variability shows the systematic difference among different observers and is expressed as the kappa (κ) coefficient. In this study, we aimed to determinate the inter-observer variability among emergency physicians in the use of DW-MRI for the diagnosis of acute ischemic stroke.

Methods

Cranial DW-MRI images of 50 patients were interpreted in this retrospective observational cross-sectional study. Patients who were submitted to DW-MRI imaging for a suspected acute ischemic stroke were included in the study, unless the scans were ordered by any of the reviewers or they were absent in the system. The scans were blindly and randomly interpreted by four emergency physicians. Inter-observer agreement between reviewers was evaluated using Fleiss' κ statistics.

Results

The mean kappa value for high signal on diffusion-weighted images (DWI) and for reduction on apparent diffusion coefficient (ADC) were substantial ($\kappa=0.67$) and moderate ($\kappa=0.60$) respectively. The correlation for detection of the presence of ischemia and location was substantial ($\kappa: 0.67$). There were 18 false-positive and 4 false-negative evaluations of DWI, 15 false positive and 8 false-negative evaluations of ADC.

Conclusions

Our data suggest that DW-MRI is reliable in screening for ischemic stroke when interpreted by emergency physicians in the emergency department. The levels of stroke identification and variability show that emergency physicians may have an acceptable level of agreement.

Key words: Emergency department; diffusion weighted magnetic resonance imaging; inter-observer agreement, ischemic stroke.

Introduction

Clinical diffusion neuroimaging, introduced in the early 1990s, was quickly adopted in the evaluation of suspected acute ischemic brain injury.^[1] Diffusion-weighted magnetic resonance imaging (DW-MRI) is a highly sensitive tool for the detection of early changes in water diffusion that characterize many brain pathologies, including acute ischemic

stroke and is excellent at detecting small and early infarcts. These changes represent variations in the random motion of water molecules in tissues. They are expressed, in diffusion-weighted images (DWI), as changes in MRI signal intensity or as variations in the apparent diffusion coefficient (ADC) of water.^[2-5] Acute ischemic stroke is characterized by very high signal on DWI and marked reduction in ADC values. In stroke

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patients, reduced diffusion can be observed within minutes to less than 1 hour after witnessed ictus, before any findings are apparent on conventional MRI.^[5] The appearance of DWI/ADC depends on the timing. Acute (0–7 days) findings of ischemic stroke in DWI are; a decrease in ADC value with maximal signal reduction at 1 to 4 days (hypo-intensity on ADC images), marked hyperintensity on DWI (a combination of T2 and diffusion weighting), and less hyperintensity on exponential images.^[5,6]

DW-MRI can show hyperacute ischemic stroke which cannot be seen on computed tomography (CT); moreover, it only takes few minutes to scan and should be considered when the emergency physician evaluates a patient with acute ischemic stroke.^[7] Lövblad et al reported a sensitivity of 88% and a specificity of 95% for DW-MRI.^[8]

As high as these values are, there are also reports of negative DW-MRI studies in cases of clinically proven ischemic stroke.^[9,10] Sylaja et al reported a 25% false negative report rate of DW-MRI in stroke and stroke like deficits.^[11] Additionally, as in all imaging modalities, DW-MRI is also interpreter dependent to some degree, especially when evaluated by non-radiologist interpreters. Inter-observer variability is the reflection of this dependency and is defined as the systematic differences among different observers and expressed as the kappa (κ) coefficient.^[12]

The primary aim of this study was to determine the inter-observer variability among emergency physicians in the use of DW-MRI for the diagnoses of acute ischemic strokes.

Materials and Methods

This retrospective observational cross-sectional study was performed in xxx University xxx Hospital. Images selected from all cranial DW-MRI examinations that were referred to the Radiology Department of xxx University School of Medicine with suspected acute ischemic stroke from 01.06.2013-01.01.2014. Local ethics committee approval was obtained prior to data collection. Data were obtained from Medin© v3.1.24.115 software. The inclusion criterion was suspected acute ischemic stroke in patients who were submitted to DW-MRI imaging. The exclusion criterion was absence of DW-MRI imaging or DW-MRI scans ordered by any of the reviewers. The scans were interpreted by four emergency physicians separately in a blind and random fashion under emergency departments (ED) conditions, where actual cases were being evaluated. Reviewers were unaware of the official radiology report and patients' clinical status at the time of imaging. All reviewing physicians were emergency physicians and have the designation of assistant professor and more than 5 years' experience in their specialty. The reviewers were trained by the radiology department for interpretation of DWI-MRI for

two hours. Also, the emergency medicine residency program in xxx have at least a one month mandatory radiology rotation. Most of the hospitals do not have a radiologist and neurologist for 24 hours in xxx, therefore many emergency physicians have to interpret their patients' scans and activate the stroke protocol themselves according to the local hospital protocols.

The following parameters were taken into consideration:

- a- High signal on DWI
- b- Marked reduction on ADC values
- c- Location of these findings

The reviewers noted on the mentioned parameters as present or absent. Inter-observer agreement between reviewers was evaluated using Fleiss' κ statistics. The kappa coefficient measures pairwise agreement among a set of interpreters making category judgments, correcting for expected chance agreement.^[13] The agreement on interpreter opinions are supposed to be acceptable beginning at a correlation co-efficient of 0.41–0.60 (Table 1).^[14,15] Later, reviewers' interpretations were compared to official radiology reports; the radiologists had more than 10 year experience in cranial radiology.

MRI Protocol

All MRI scans were performed on a Siemens 1.5 Tesla Avanto® MRI scanner using 4-mm slice thickness; B-0, B-1000 mm²/sec images and ADC.

Statistical Analysis

Kappa statistics on <https://www.statstodo.com> were used to evaluate the inter-observer agreement. StatsToDo® website provides free statistics calculators for clinical research and quality control.

Results

There were 97 patients who underwent DWI-MRI between 01.06.2013-01.01.2014. Images of 47 patients were ordered by one of the reviewers and these were excluded from the study, leaving 50 patients for further evaluation. The mean kappa value for high signal on DWI and for reduction on ADC were $\kappa=0.67$ (0.56-0.78) and $\kappa=0.60$ (0.49-0.71) respectively. The inter-observer agreement between reviewers was substantial for high signal on DWI and moderate for reduction on ADC respectively. Accuracy of diagnosis for reviewers one to four, according to the official radiologist's reports, were 88%, 90%, 80% and 86% for ischemic stroke (mean accuracy rate: 86%) respectively. Correlation between the reviewers was substantial (κ : 0.67) in detecting the presence of ischemia

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