# Accuracy of Diffusion-Weighted Imaging in the Diagnosis of Stroke in Patients With Suspected Cerebral Infarct

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***Background and Purpose***—The accuracy of diffusion-weighted imaging (DWI) for the diagnosis of acute cerebral ischemia among patients with suspected ischemic stroke arriving to an emergency room has not been studied in depth.

***Methods***—DWI was performed in 712 patients with acute or subacute focal symptoms that suggested an acute ischemic stroke (AIS), 609 of them with AIS.

***Results***—DWI demonstrated a sensitivity of 90% and specificity of 97%, a positive likelihood ratio of 31 and a negative likelihood ratio of 0.1 for detecting AIS. The overall accuracy was 95%. Of those patients who demonstrated abnormal DWI studies, 99.5% were AIS patients, and of those patients with normal DWI studies 63% were stroke mimics.

***Conclusions***—DWI is accurate in detecting AIS in unselected patients with suspected AIS; a negative study should alert for nonischemic conditions. (***Stroke***. 2013;44:1169-1171.)

**Key Words:** diagnosis ■ diffusion-weighted imaging ■ stroke

Diffusion-weighted imaging (DWI) is a sensitive technique for the diagnosis of acute ischemic stroke (AIS), but yields false-negative results when applied early after symptom onset or if these are small.[1–5] Most studies demonstrating the usefulness of DWI in the diagnosis of AIS have been carried out in a series of consecutive ischemic stroke patients, or in which normal subjects served as control group, or the sample sizes were small and retrospective.[1,6,7] Furthermore, stroke mimics (SM) occasionally yield positive DWI studies.[1] The accuracy of DWI in the detection of AIS in unselected patients arriving to an emergency room (ER) with focal symptoms suggestive of AIS, where there could be SM, has not been studied in detail.

In this short communication, we aimed at calculating the likelihood that DWI will detect AIS in a large, unselected series of patients arriving to an ER with acute symptoms suggestive of brain ischemia.

## Methods

In this prospective study, all patients with suspected AIS admitted to the emergency department of Clínica Alemana de Santiago between December 2004 and March 2011 were evaluated by the neurologist on call within the first 15 to 30 minutes after arrival. After this clinical evaluation, stroke severity was assessed applying the National Institute of Health Stroke Scale, blood samples were obtained and an ECG was performed. Patients were then studied with a neuroimaging protocol, which has been previously described,[8] consisting of a brain computed tomography and, in those patients without contraindications, a spiral computed tomographic angiography of the intracranial arteries and then DWI. The neuroradiologist on call was informed about the admission of a stroke patient and the location of the suspected lesion.

DWI examinations were performed using a 1.5-Tesla Signa whole-body scanner (GE Medical Systems, Milwaukee, WI), equipped with echo-speed gradients; the acquisition parameters were repetition time (TR), 1000 ms; spin time echo (TE) 73.9 ms; matrix 128! 128; field of view 36×23 cm; 32 oblique sections with a thickness 5 mm; without intervals. The diffusion images were obtained with a diffusion weight (b) of 1000 s/mm$^2$ and sensitivity gradients of diffusion in planes *x*, *y*, and *z*.

Stroke was diagnosed in patients with a history, clinical examination, and evolution typical of vascular brain damage, with signs of brain ischemia on computed tomography/DWI in our stroke neuroimaging protocol, or on follow-up imaging, or if an occluded vessel was observed in the symptomatic territory. Patients with repeated negative imaging, but with an evident neurovascular syndrome, and no other alternative diagnosis after extensive workup were finally diagnosed as stroke.

The diagnosis of SM was based on the presence of focal acute or subacute neurological symptoms with a definite diagnosis different from stroke explaining the patient's initial symptoms, and when the diagnosis of stroke had been ruled out.

The Ethics Committee of Universidad del Desarrollo, Clínica Alemana de Santiago approved the protocol.

## Statistical Analysis

Sensitivity, specificity, and their respective 95% confidence intervals (CIs) likelihood ratios, as well as diagnostic accuracy

**Table.    Baseline Characteristics and Comparison Between Strokes and Stroke Mimics**

| | Stroke Mimics, n=113 | Stroke, n=729 | OR, 95% CI | *P* Value |
|---|---|---|---|---|
| Mean age, years (SD) | 67.1 (±14.66) | 71.1 (±16.2) | | 0.01 |
| Women | 63 (55.7%) | 359 (49.2%) | | <0.001 |
| Time to DWI minutes (median) | 507 (35–5775) | 195 (33–7215) | | 0.03 |
| Mean admission NIHSS (SD), median NIHSS | 4.7(±3.3), 1 (IQR 0–6) | 7 (±6.7), 4 (IQR 2–9) | | <0.001 |
| Hypertension (%) | 41 (36.3%) | 461 (63.2%) | 0.47 (0.27–0.67) | 0.001 |
| Diabetes mellitus (%) | 74 (65.5%) | 150 (20.6%) | 2.04 (1.3–2.1) | 0.001 |
| Hypercholesterolemia (%) | 27 (23.9%) | 216 (29.6%) | 0.74 (0.5–1.1) | 0.2 |
| Tobacco (%) | 26 (23%) | 140 (19.2%) | 1.25 (0.77–2.1) | 0.4 |
| Ischemic heart disease (%) | 31 (27.4%) | 236 (32.4%) | 0.65 (0.4–1.0) | 0.08 |
| DWI done N (%) | 103 (91.5%) | 609 (88.6%) | | |
| DWI positive N (%) | 3 (2.6%) | 551 (90.4%) | | 0.002 |

CI indicates confidence interval; DWI, diffusion-weighted imaging; NIHSS, National Institute of Health Stroke Scale; and OR, odds ratio.

were calculated to estimate DWI validity in detecting AISs, among the unselected patients arriving to an ER with focal symptoms suggestive of AIS.

## Results

Between December 2004 and March 2011, 842 patients with suspected AIS were admitted in our center. Of these, 729 were AIS and 113 were finally given a diagnosis of SM. Table compares the baseline characteristics of these 2 groups.

Of the 729 patients with AIS, 609 (88.6%) had a DWI performed, and of these, 551 (90.4%) had an image compatible with an ischemic stroke.

In the group of 113 patients who finally were diagnosed with a SM, DWI was performed on 103 patients (91.5%) with 3 cases (2.9%) resulting in abnormal findings: one was a patient with a brain tumor and the other two had herpetic encephalitis in one case and white matter disease in the other.

Among patients with a suspected ischemic stroke, DWI had a sensitivity of 90% (95% CI, 87.9–92.6), and specificity of 97% (95 CI%, 91.8–99) for the detection of an AIS, accuracy was 95%. The positive likelihood ratio was of 31 (95% CI, 10.1–94.7), and the negative likelihood ratio was 0.1 (95% CI, 0.077–0.126).

Of those patients who had abnormal DWI studies, 99.5% were stroke cases, and of those patients with normal DWI studies, 63% were SM.

There were 58 patients with AIS and a negative initial DWI; follow-up brain imaging studies were performed after 24 hours, MRI in 34 patients and a repeat computed tomography/DWI in 24 cases. In 31 cases, images compatible with the diagnosis of stroke were observed. Patients with negative follow-up imaging had a lower National Institute of Health Stroke Scale: median 3 (IQR, 1–11), and 37% of these lesions were considered to be small brain stem strokes.

Imaging studies were negative in 20 (3.8%) of all stroke cases (acute and follow-up parenchymal studies, in addition to vascular imaging computed tomographic angiography and transcranial doppler) and were considered cases of stroke based on a clinical diagnosis.

## Discussion

Our experience demonstrates that DWI is accurate in detecting AIS in unselected patients arriving to an ER with focal symptoms suggestive of this condition. Despite the fact that along a 6-year period almost 1 out of every 7 patients (13.4%) who presented to our ER had an alternative diagnosis to stroke, DWI demonstrated a diagnostic accuracy of 95% and a positive likelihood ratio over 10, which points to a large and often conclusive increase in the likelihood of an ischemic stroke and negative likelihood ratios of 0.1, indicating a low probability of acute stroke when this test was normal. Indeed, patients who had normal DWI studies were SM in 63% of cases.

Based on these results, a negative DWI study should alert the clinician to search for nonischemic conditions if the symptoms suggest AIS, but should not delay intravenous thrombolysis as 9.6% of our stroke patients had negative DWI examinations. The effect of thrombolysis is time-dependent and SM patients have a favorable prognosis if treated.[9,10]

Our study has some limitations; mainly that it is a single-center experience, and we cannot exclude that, in some cases, DWI was used to categorize the patients as having an AIS.

## Sources of Funding
None.

## Disclosures
None.

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