Neurological Evaluation and Diffusion-Weighted MRI Assessment of Patients with Transient Ischemic Attacks

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ABSTRACT

Background: The risk of stroke after a transient ischemic attack (TIA) is high. Appropriately directed therapies may reduce this risk. However, sensitive means of detecting the presence of transient neuronal ischemia are lacking.

Objective: To analyze the incidence of ischemic lesions detected by using diffusion-weighted MR imaging in patients suffering from transient ischemic attacks (TIA), and to determine whether the presence of a diffusion image abnormality and their neuro-anatomical location correlates with the clinical presentation and duration of symptoms.

Methods: Thirty six patients presented with TIA underwent diffusion-weighted MR imaging within 24 hours of symptoms. Results: Twenty six patients (72.3%) had normal DW images while 10 patients (27.7%) showed positive lesions. It was found that, although there was slightly longer median symptom duration in patients with positive DWI compared to negative cases, it was of no statistically significant difference. The anatomical location of the positive cases was matching with their clinical neurological presentation. Conclusion: Accordingly, we can consider that patients with TIAs are at high risk of early stroke, and their risk can be evaluated by clinical scale, and diffusion magnetic resonance imaging.

Key Words: Transient ischemic attack, diffusion weighted MRI.

INTRODUCTION

A transient ischemic attack (TIA) is an acute neurologic syndrome of vascular etiology that resolves within 24 hours. Other paroxysmal disorders such as focal seizures, migraines, and transient global amnesia can mimic TIA. The accurate diagnosis of TIA is important because, depending on the underlying mechanism, the stroke risk can be as high as 40% in the subsequent 2 years.

Conventional MR images may not show positive findings in cases of ischemic infarction for 8 to 12 hours after onset, a time period beyond that when neuroprotective drugs are most likely to be given and more likely to be effective. Diffusion weighted MR images, on the other hand, can show regions of ischemic injury within minutes after stroke onset. Studies of diffusion-weighted imaging in humans suffering acute stroke have confirmed the diagnostic capability and superiority of this technique relative to conventional MR T2-weighted imaging within the first few hours after stroke onset.

Diffusion-weighted imaging (DWI) techniques rely on the principle that the cytotoxic edema induced by cerebral infarction changes the nature of the microscopic diffusion of water. As sodium pump failure is induced by ischemia, progressive intracellular cytotoxic edema occurs. This diffusion deficit is detected as an area of high signal intensity on DW images.

Brain imaging has challenged the assumption that because clinical transient ischemic attack (TIA) symptoms resolve, significant ischemic tissue does not occur. MR imaging using diffusion-weighted imaging (DWI) reveals an ischemic lesion in approximately half of all TIAs (range, 21%–67%) with the probability of DWI positivity increasing with the duration of symptoms.

The aim of this study was to analyze the incidence of ischemic lesions detected by using diffusion-weighted MR imaging in patients suffering from transient ischemic attacks (TIA), and to determine whether the presence of a diffusion image abnormality and their neuro-anatomical location correlates with the clinical presentation and duration of symptoms.
SUBJECTS AND METHODS

Thirty six patients with TIA were studied (26 men and 10 women) with the age range of 52 to 82 (mean 64.7±9.1 years).

The following clinical data were collected for all patients:
- Age, sex, symptoms of TIA.
- Estimation of TIA duration was available through knowing the time of symptoms onset and time of symptoms resolution.
- History of previous clinical TIA or stroke.
- Presence of vascular risk factor as hypertension, coronary heart disease, diabetes mellitus or hypercholesterolemia.
- History of tobacco use.
- Previously performed vascular studies on the examined patients as echocardiography, carotid Doppler ultrasound or angiography.

The clinical diagnosis of TIA was applied if the patient had completely reversible neurological symptoms within 24 hours, that were sudden in onset and if there was no observed seizure or seizure-like movement, no history of established epilepsy and no history of migraine.

Neuro-anatomical location was noted for all patients, hemispheric symptoms (e.g. aphasia, neglect, isolated hand or arm weakness) and subcortical or brain stem ischemia were included.

Methods:
All patients were scanned within 24 hours of onset of signs and symptoms.

MR imaging was performed with either a panorama 0.23-T (Philips MRI whole-body system) having DWISE and TDWISE diffusion weighted imaging protocols or a 3-T (Philips Achieva MRI system) using DWISE protocol.

For the 0.23-T system the following sequence parameters were used: Axial T2-weighted turbo spin-echo (3700/90/2), T1-weighted spin-echo (550/10/2), turbo fluid attenuated inversion recovery (FLAIR) (9000/110/2), and DWISE diffusion-weighted sequences were performed.

For the 3-T system the following sequence parameters were used: Axial T2-weighted turbo spin-echo (3000/80/2), T1-weighted spin-echo (500/10/2), turbo fluid attenuated inversion recovery (FLAIR) (11000/125/2), and DWISE diffusion-weighted sequences were performed.

The diffusion-weighted images were obtained with a single shot spin-echo echo-planar pulse sequence with diffusion gradient b values of 1000/ROT along all three orthogonal axes over 20 axial sections, 5.5-mm-thick sections, 230-mm field of view, and 112 X 89 matrix.

Statistical Methods
Data was coded and entered using the statistical package SPSS version 15. Data was arranged using number and percentage for qualitative variables, and mean, standard deviation and range for quantitative variables.

Comparisons between groups was done using chi-square test for qualitative variables, independent sample T test for normally distributed qualitative variables, while non parametric Mann Whitney test was used for non normally distributed qualitative variables.

Logistic regression analysis was done to test for significant predictors for infarction.

P-values less than or equal to 0.05 were considered as statistically significant.

RESULTS

Ten out of 36 patients (27.7%) had positive lesions detected by DWI, for the remaining 26 patients (72.3%), DWI was negative.

The study included 26 males (72.2%) and 10 females (27.8%). Positive DWI was found in two females (20% of females), and eight males (30.8% of males). P-value showed there was no statistically significant difference between males and females with positive lesions in DWI.

The mean age for patients with negative DWI was 64.8±8.9, and for patients with positive DWI it was 64.4±9.8; and there was no statistically significant difference between the two groups.

The mean duration of presenting symptoms was 2±2.7 hours in patients with negative DWI, while it was slightly higher; 2.75±3.5 hours in patients with positive DWI. But there was no statistically significant difference between the two groups.
The clinical, neuroanatomical and vascular localization in the positive 10 patients revealed the following:
- The longest time of persistent clinical symptoms was 12 hours in one patient.
- The shortest time reported was ½ hour in 3 patients.
- The median duration of clinical symptoms was 2.75 hours.

Seven patients out of 10 had risk factor profiles that placed them at high risk for cerebral ischemia. These risk factors were: 4 patients had hypertension (2 of them suffered from diabetes mellitus as well), 1 patient had coronary heart disease, 2 patients had hyperlipidemia, and 2 patients were cigarette smokers.

Seven patients had DWI detectable hemispheric ischemic lesions, 2 of which were cortical in location, brain stem ischemic foci were identified in 2 patients, while a single patient had a cerebellar ischemic lesion.

The following table demonstrates the neurological presentation, duration of TIA and risk factors.

Logistic regression analysis was done to test for significant predictors for occurrence of infarction (positive DWI) among TIA patients in the study. Age, duration of symptoms and gender was entered in the regression model and tested as a predictor for the occurrence of infarction. However none of them was a significant predictor for infarction.

Figure 1-6 shows DW images from six patients included in the study.

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age/sex</th>
<th>Risk Factor</th>
<th>Symptom duration (Hours)</th>
<th>Clinical presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>58/M</td>
<td>Hyperlipidemia &amp; cigarette smoker</td>
<td>0.5 h</td>
<td>Right upper limb monoparesis</td>
</tr>
<tr>
<td>2</td>
<td>72/M</td>
<td>Hypertension &amp; diabetes mellitus</td>
<td>1 h</td>
<td>Non fluent aphasia</td>
</tr>
<tr>
<td>3</td>
<td>54/M</td>
<td>Hyperlipidemia</td>
<td>4 h</td>
<td>Fluent aphasia &amp; right hemiparesis</td>
</tr>
<tr>
<td>4</td>
<td>59/M</td>
<td>Hypertension &amp; diabetes mellitus</td>
<td>1 h</td>
<td>Left facial weakness, dysarthria</td>
</tr>
<tr>
<td>5</td>
<td>62/M</td>
<td>Hyperlipidemia</td>
<td>3 h</td>
<td>Right sided numbness &amp; weakness</td>
</tr>
<tr>
<td>6</td>
<td>69/F</td>
<td>Hypertension &amp; diabetes mellitus</td>
<td>12 h</td>
<td>Left hemiparesis</td>
</tr>
<tr>
<td>7</td>
<td>52/M</td>
<td>Hypertension &amp; diabetes mellitus</td>
<td>0.5 h</td>
<td>Right Face, arm and leg numbness</td>
</tr>
<tr>
<td>8</td>
<td>60/M</td>
<td>Cigarette smoker</td>
<td>0.5 h</td>
<td>Vertigo, gait ataxia</td>
</tr>
<tr>
<td>9</td>
<td>82/M</td>
<td>Coronary heart disease &amp; hypertension</td>
<td>2 h</td>
<td>Non fluent aphasia</td>
</tr>
<tr>
<td>10</td>
<td>76/F</td>
<td>Hypertension</td>
<td>3 h</td>
<td>Right hemiparesis</td>
</tr>
</tbody>
</table>

**Table 1.** Clinical presentation duration of symptoms and risk factors.

**Figure 1.** A 54 years old male presented with fluent aphasia and right hemiparesis for 4 hour duration, DWI showing left temporo-parietal ischemic area.

**Figure 2.** A 58 years old male with right monoparesis for 0.5 hours duration, DWI showed left parietal ischemic focus.
DISCUSSION

Neuroradiologic investigations with CT and conventional MR imaging have shown that a substantial proportion of patients with TIAs have ischemia-related lesions of the brain parenchyma\textsuperscript{11,12}. These studies, however, have been handicapped by their low sensitivity in detecting acute and small infarctions and differentiating acute lesions from prior unrelated ischemic events\textsuperscript{11,13}. Thus, the identification of a particular brain lesion attributable to the actual ischemic event remains difficult with these imaging techniques.

Diffusion-weighted MR imaging on the other hand has high sensitivity and specificity for early detection of ischemic lesions\textsuperscript{14}. It also provides temporal information, because acute lesions are bright compared with normal brain tissue or old ischemic events in isotropic diffusion-weighted images. This excellent background suppression permits the detection of even very small, acute infarction at almost any anatomic location within the brain hemispheres, brain stem, and cerebellum. Previous reports have shown that the addition of diffusion-weighted imaging to the conventional MR examination in patients with small-vessel infarctions substantially increases the detection of clinically relevant infarcts\textsuperscript{15}. Analysis of diffusion-weighted MR imaging in patients with TIAs helps detecting acute ischemic lesions in approximately two thirds of cases (67%)\textsuperscript{16}.

In our study the incidence of positive DWI scans for patients with TIA was 27.7% compared to
21%\textsuperscript{10}, 48%\textsuperscript{9}, 35%\textsuperscript{17}, 67%\textsuperscript{16}, and 37%\textsuperscript{18} of patients in other studies. The differences in the prevalence of DWI-detected abnormalities in our opinion is related to differences in the patient populations studied, differences in the time to MRI scan, and variations in both the type and severity of neurological symptoms between different studies.

Prior studies\textsuperscript{9,16} substantiate the hypothesis that longer TIA symptom duration is associated with an increased likelihood of a positive DWI scan. The relationship between symptom duration and DWI positivity makes theoretical sense since longer duration of symptoms would be expected to result in a higher probability of persistent parenchymal damage that could be detected by MRI.

However, symptom duration alone may be an inadequate determinant of DWI positivity. In another later study\textsuperscript{19}, the minimum symptom duration in a patient with positive DWI scan reported was 40 seconds. This is significantly lower than the shortest duration of 10 minutes previously reported\textsuperscript{16}. In addition, 10% of patients with symptom duration of below 5 minutes demonstrated a positive DWI scan. Thus, symptom duration alone appears to be an imperfect predictor of DWI scan positivity. In our study the mean duration of presenting symptoms was 2\pm2.7 hours in patients with negative DWI, while it was slightly higher; 2.75\pm3.5 hours in patients with positive DWI. But there was no statistically significant difference between the two groups.

The type of neurological symptom may have a profound effect on the probability of DWI positivity. Similarly, the relationship between symptom severity and DWI positivity has not been adequately evaluated. It seems likely that symptom severity would have a substantial effect on DWI positivity. However, this hypothesis is difficult to test retrospectively. Sensory symptoms were not associated with a positive DWI scan\textsuperscript{10}. They are often viewed as "soft" symptoms because they are subjective. In addition, sensory symptoms may be associated with a broad range of possible etiologies such as hyperventilation, seizure, migraine, or multiple sclerosis\textsuperscript{10,20}. This may explain why patients presenting with sensory symptoms did not have a greater likelihood of abnormal DWI imaging. None of our positive DWI patients had pure sensory symptoms. On the other hand the neuro-anatomical location of our positive DWI patients was matching their neurological symptoms and clinical presentation.

**Conclusion**

The use of diffusion-weighted MR imaging in the acute phase of TIA appears to be clinically useful and does not significantly increase the total examination time. It is more sensitive than is conventional MR imaging in detecting TIA-related lesions and confirms their ischemic origin in most cases. Diffusion weighted MR imaging also defines the size, number, and location of the lesion(s) as well as the vascular territory involved, all of which may be useful in determining TIA cause, guiding therapy, and initiating long-term secondary stroke preventative therapy. Moreover, the identification of which patients have a new infarct on images may have important prognostic value.

**[Disclosure: Authors report no conflict of interest]**

**REFERENCES**

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