

ORIGINAL ARTICLE

Emergency department experience of primary diffusion weighted magnetic resonance imaging for the patient with lacunar syndrome

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Background: The purpose of this study was to evaluate the usefulness of a particular magnetic resonance imaging technique known as primary diffusion weighted imaging (DWI) for patients with lacunar syndrome in the emergency department (ED).

Methods: Patients with one of five classic lacunar syndromes underwent DWI as primary imaging modality. The DWI findings were classified into groups: (a) having a lesion with high signal intensity, (b) having a lesion with mixed signal intensity, and (c) unremarkable. The final clinical diagnoses were extracted from the patients' medical records, and used as a reference standard.

Results: Of 151 DWI images, 120 (79%) were interpreted as high signal lesions, 21 (14%) as mixed signal lesions, and 10 (7%) as unremarkable. All patients with high signal lesions or unremarkable findings were diagnosed with ischaemic stroke. The patients with mixed signal lesions were diagnosed with haemorrhagic stroke with an exception of one ischaemic stroke.

Conclusion: Primary DWI is a feasible and useful neuroimaging tool for patients with lacunar syndrome in the ED.

A non-contrast computed tomography (CT) scan is the standard method to diagnose stroke, with door to CT scan time usually being <25 minutes for potential fibrinolytic cases.¹ CT scans can show negative results in acute ischaemic stroke patients, however, more advanced diagnostic studies are frequently performed after the CT scan.

About 20% of first time stroke patients have a lacunar stroke, with a relatively good prognosis.² The five classic lacunar syndromes, established by Fisher, are pure motor stroke (PMS), ataxic hemiparesis (AH), dysarthria clumsy hand syndrome (DCH), sensorimotor stroke (SMS), and pure sensory stroke (PSS).³ Clinical lacunar syndromes are highly predictive for a small infarct.⁴ About 7% of intracerebral haemorrhages also present with lacunar syndrome, while haemorrhagic lacunar stroke accounts for 3.8% of lacunar syndromes.⁵ It is difficult to clinically differentiate infarction from haemorrhage in patients with lacunar syndrome. Moreover, it is difficult to clinically estimate the location of a stroke lesion.

Although the CT scan is more sensitive in excluding a haemorrhage, a newer magnetic resonance imaging technique, diffusion weighted imaging (DWI), is very sensitive to hyperacute ischaemic stroke and intracerebral haemorrhages.^{6–8} CT angiography source images have been found to be comparable with magnetic resonance imaging (MRI) for acute ischaemic stroke, while small lacunar infarctions were only visible by initial DWI.⁹ Therefore, it is reasonable to use DWI as a primary imaging method for patients with lacunar syndrome.

We performed primary DWI in the emergency department (ED) on patients with lacunar syndrome. The purpose of this study was to evaluate the usefulness of primary DWI in diagnosing lacunar syndrome.

METHODS

Study design

This was a prospective observational study of patients receiving DWI after presenting to the ED with lacunar

syndrome. The study was reviewed and approved by the institutional review board.

Study setting and population

The study was conducted in an urban teaching hospital ED with an emergency medicine residency programme. The ED has approximately 35 000 visits per year, most of whom are East Asian patients. Patients diagnosed by the attending emergency physicians as having one of the five classic lacunar syndromes were enrolled in the study. PMS was defined as a unilateral motor deficit involving at least two of three possible areas (face, arm, and leg); PSS as any unilateral pure sensory deficit; SMS as any unilateral motor and sensory deficit; DCH as dysarthria combined with clumsiness and slowed fine movement in one hand; and AH as unilateral ataxia accompanied by motor deficit. We classified PMS and AH into the same category because hemiparesis often results in uncoordinated movement. As such, they are sometimes difficult to differentiate clinically.¹⁰

Patients were excluded based on several criteria. The first criterion was having a symptom duration <3 hours or >48 hours. Patients with a symptom duration <3 hours received a CT scan first, following standard evaluation protocol. Patients with a duration >48 hours also received the primary CT protocol, owing to a high probability of detecting lesions with a CT scan. The second exclusion criteria was presenting with additional cortical symptoms such as aphasia or neglect. Patients with suspected transient ischaemic attack also presented with lacunar syndrome, but their symptoms were improving prior to imaging and thus were excluded. Finally, patients who were unwilling to participate or had a contraindication for MRI such as

Abbreviations: AH, ataxic hemiparesis; CT, computed tomography; DCH, dysarthria clumsy hand syndrome; DWI, diffusion weighted imaging; ED, emergency department; MRI, magnetic resonance imaging; PMS, pure motor stroke; PSS, pure sensory stroke; SMS, sensorimotor stroke

pacemaker, intracranial metallic fragment, or claustrophobia were excluded. This study took place between July 2002 and June 2004.

Study protocol

The department of emergency medicine, neurology, and neuroradiology formally agreed that DWI be instituted as the first line neuroimaging for patients with suspected acute lacunar syndrome prior to the start of the study. All patients underwent limited MRI confined to a diffusion weighted sequence on a 1.5 Tesla whole body scanner (GE Signa, General Electric) with echo planar imaging data acquisition capability (Advanced NMR Systems) designed to obtain rapid images. DWI was obtained as soon as possible after informed consent was given. The pulse sequence for DWI was a single shot, spin echo sequence with an echo time of 71.8 ms, a 128×128 matrix, a 200–240 mm field of view, and 5 mm slice thickness with no gap between the 20 sections covering the whole brain. The two b values were 0 and 1000 s/mm². Apparent diffusion coefficient maps were not routinely acquired.

A neuroradiologist blinded to the clinical information interpreted the DWI films. If necessary, the patient underwent further diagnostic studies following neurology department protocol. The final clinical diagnoses were extracted from the patient's medical records, and used as a reference standard. These diagnoses were based on clinical assessment and neuroimaging without an attempt to blind the neurologist to the DWI results.

Data analysis

The DWI findings were classified into groups: (a) having a lesion with high signal intensity, (b) having a lesion with mixed signal intensity, and (c) unremarkable. Anything without a high or mixed signal intensity, such as inconclusive faint signals, was considered unremarkable. The lesions with high and mixed signals were considered to be acute ischaemic and haemorrhagic stroke, respectively.

Demographic data and time intervals of examinations were given as mean values with SD. For statistical analysis we used the Mann-Whitney *U* test and χ^2 test to determine whether there were significant differences in time interval and demographic data between unremarkable and DWI positive groups, using SPSS software (SPSS Inc, Chicago, IL, USA).

RESULTS

Patients

Data were collected from 212 patients with lacunar syndrome over the 2 year period. Of these, 61 patients were excluded. The reasons for exclusion were: symptom duration <3 hours (5 patients) or >48 hours (25), additional cortical symptoms (9), improving symptoms (5), refusal to consent to MRI (13),

and equipment failure (4). One patient visited twice during the period. Therefore, 151 lacunar syndromes from 150 patients were analysed.

The mean (SD) age was 64.9 (10.7) years (range 27 to 91), comprising 96 men and 54 women (sex ratio 1.8:1). Of the 151 lacunar syndromes classified, 94 (62%) were PMS/AH, 35 (23%) SMS, 17 (11%) DCH, and 5 (3%) PSS. Final diagnosis was ischaemic stroke for 131 patients and haemorrhagic stroke for 20 (table 1).

DWI diagnoses

From 151 DWI images, 120 were interpreted as high signal lesions, 21 mixed signal lesions, and 10 unremarkable. All patients with high signal lesions or unremarkable findings were diagnosed with ischaemic stroke. The patients with mixed signal lesions were diagnosed with haemorrhagic stroke with an exception of one ischaemic stroke. The results of DWI and final diagnoses were displayed using an algorithm (fig 1).

There were no differences in time interval from symptom onset to MRI between unremarkable (19.4 (13.6) hours) and positive (16.2 (14.6) hours) MRI groups. There were also no differences in age (65.6 (13.9) years), sex (six men, four women), or lesion subtype (five PMH, five SMS).

DISCUSSION

Lacunar syndrome usually suggests a lacunar infarct, defined as a small deep infarct with a maximum diameter of 15 mm. In this study, 87% of the patients with lacunar syndrome had lacunar infarcts, and all others had a small haemorrhagic stroke. PMS/AH was the most abundant lacunar syndrome, followed by SMS, DCH, and PSS, in that order. These frequencies are consistent with other reports.¹¹

In patients with lacunar syndrome, routine CT scans were only positive in 30–50% of cases.^{2–12} MRI has been considered a redundant test for lacunar syndrome when a CT scan excludes non-ischaemic causes of stroke.⁴ Using a rapid echoplanar technique allows examination times comparable to CT, thus making MRI a feasible alternative in routine practice when the study is confined to a diffusion weighted sequence. In this study, primary DWI showed a relevant lesion in 120 of 131 confirmed lacunar infarcts (91.6%). Lai *et al* showed the sensitivity of DWI for acute lacunar infarcts to be as high as 95%, with specificity 94%, positive predictive value 97%, and negative predictive value 90%.¹³ Lindgren *et al* found that 22 of 23 patients (96%) with clinical lacunar syndromes showed lesions on DWI, consistent with a lacunar infarct.¹⁴

Although DWI is known to have a higher sensitivity and specificity for lacunar infarction than a CT scan, false negatives are also reported.¹⁵ Our study revealed 10 cases in which the final diagnosis was infarction, but no high signal lesions appeared on DWI. Six of these cases had relevant

Table 1 Final diagnoses and DWI findings according to type of lacunar syndrome

	Lacunar syndrome				Total (%)
	PMS/AH	SMS	DCH	PSS	
Diagnosis					
Ischaemic stroke	81	28	17	5	131 (87)
Haemorrhagic stroke	13	7	0	0	20 (13)
DWI finding					
High signal intensity	76	22	17	5	120 (79)
Mixed signal intensity	13	8	0	0	21 (14)
Unremarkable	5	5	0	0	10 (7)
Total (%)	94 (62)	35 (24)	17 (11)	5 (3)	151

DWI, diffusion weighted imaging; PMS, pure motor stroke; AH, ataxic hemiparesis; SMS, sensorimotor stroke; DCH, dysarthria clumsy hand syndrome; PSS, pure sensory stroke.

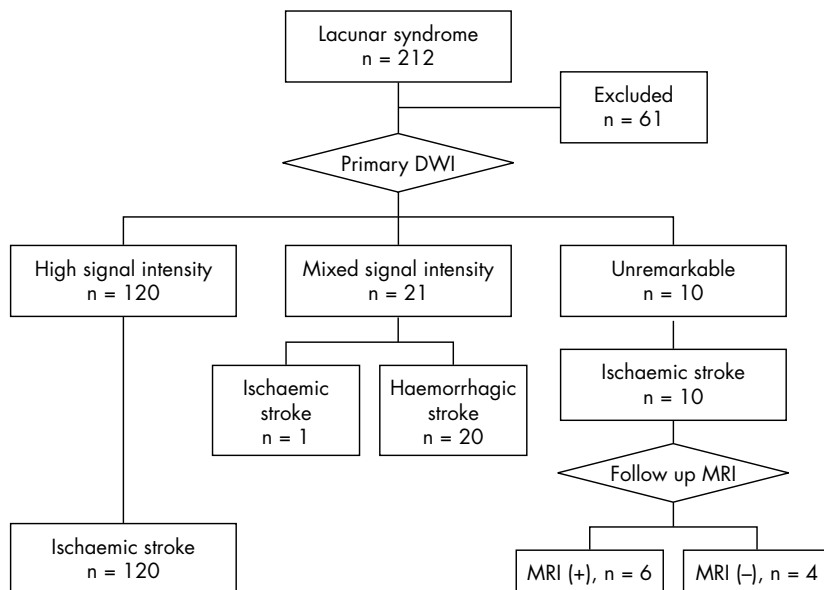


Figure 1 The final diagnoses of the patients are shown according to DWI findings.

lesions discovered on a follow up MRI. The remaining four patients also obtained unremarkable findings on the follow up MRI. Their final diagnoses were made according to persistent clinical findings. One possible explanation for false negatives is that the lacune size is too small to cut with a DWI slice.

One case showed a false positive mixed signal lesion that confirmed a recurrent infarction in an adjacent area (fig 2). False positive DWIs for ischaemic stroke are very rare. Mullins *et al* reported that only one false positive was discovered from 411 images, possibly due to the “T2 shine through effect”.¹⁶ We used an algorithm to describe test results instead of using sensitivity and specificity because the results could not simply be divided into positive or negative. Both lesions with high and mixed signals were considered positive for stroke.

In this study, the lacunar infarcts mainly occurred in the basal ganglia, pons, corona radiata, thalamus and internal capsule. It is well known that lacunar syndrome type does not correlate with anatomical location.¹¹ The same type of lacunar syndrome can be caused by lesions in a variety of locations. Furthermore, lesions that appear to be in the same location can give rise to different lacunar syndromes. Nine patients showed multiple lacunes on DWI. Multiple lacunes are seen in about 16% of lacunar infarctions, and suggest an embolic stroke mechanism.¹⁷

We have restricted our primary DWI study to classic lacunar syndrome. There are other atypical lacunar syndromes such as hemiballism and internuclear ophthalmoplegia.³ We believe that such patients may also be primary DWI candidates. Making use of MRI equipment more feasible in the ED would allow primary DWI to be used on many suspected stroke patients in the near future.

Limitation and future questions

There are several limitations to our study. Firstly, the study has no pathological heterogeneity other than stroke. All small lesions (brain tumour, infections, and neurosurgical procedure) regardless of the aetiology can produce lacunar syndrome. Moreover, the 13% haemorrhagic stroke rate in this study is much higher than in other reports.⁵ This discrepancy may be due to the differences in the patient populations. Secondly, being observational, this study was not able to compare DWI with a standard imaging modality, such as CT. Future studies should be larger, randomised, and compared with the current stroke evaluation algorithms on the basis of improving patient important outcome, cost effectiveness and diagnostic performances.

CONCLUSION

Primary DWI is a useful neuroimaging tool for patients with lacunar syndrome in the ED. Although more studies are

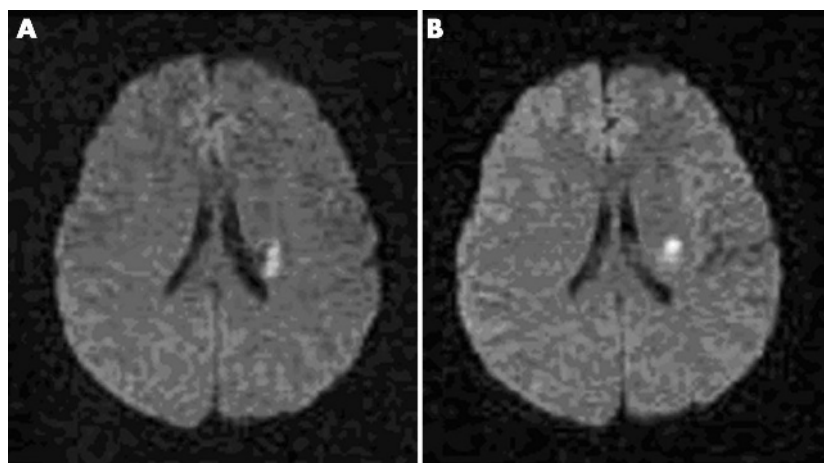


Figure 2 False positive for haemorrhage on DWI. (A) The DWI of a 60 year old man with pure motor stroke shows a lesion with mixed signal intensity, which indicates haemorrhage in the left basal ganglia. (B) The DWI of the same patient presented signs of pure motor stroke 3 months previously, showing a lesion with high signal intensity compatible with infarct in the adjacent area.

required, primary DWI may be another diagnostic option for lacunar syndrome.

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