Magnetic resonance imaging and computed tomography in emergency assessment of patients with suspected acute stroke: a prospective comparison

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Summary

Background Although the use of magnetic resonance imaging (MRI) for the diagnosis of acute stroke is increasing, this method has not proved more effective than computed tomography (CT) in the emergency setting. We aimed to prospectively compare CT and MRI for emergency diagnosis of acute stroke.

Methods We did a single-centre, prospective, blind comparison of non-contrast CT and MRI (with diffusion-weighted and susceptibility weighted images) in a consecutive series of patients referred for emergency assessment of suspected acute stroke. Scans were independently interpreted by four experts, who were unaware of clinical information, MRI-CT pairings, and follow-up imaging.

Results 356 patients, 217 of whom had a final clinical diagnosis of acute stroke, were assessed. MRI detected acute stroke (ischaemic or haemorrhagic), acute ischaemic stroke, and chronic haemorrhage more frequently than did CT ($p<0·0001$, for all comparisons). MRI was similar to CT for the detection of acute intracranial haemorrhage. MRI detected acute ischaemic stroke in 164 of 356 patients (46%; 95% CI 41–51%), compared with CT in 35 of 356 patients (10%; 7–14%). In the subset of patients scanned within 3 h of symptom onset, MRI detected acute ischaemic stroke in 41 of 90 patients (46%; 35–56%); CT in 6 of 90 (7%; 3–14%). Relative to the final clinical diagnosis, MRI had a sensitivity of 83% (181 of 217; 78–88%) and CT of 26% (56 of 217; 20–32%) for the diagnosis of any acute stroke.

Interpretation MRI is better than CT for detection of acute ischaemia, and can detect acute and chronic haemorrhage; therefore it should be the preferred test for accurate diagnosis of patients with suspected acute stroke. Because our patient sample encompassed the range of disease that is likely to be encountered in emergency cases of suspected stroke, our results are directly applicable to clinical practice.

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Introduction

Magnetic resonance imaging (MRI) is generally thought to be better than computed tomography (CT) for the diagnosis of acute stroke, but this belief has never been substantiated for the full range of patients in whom this diagnosis is suspected. Patients who present to the emergency room with stroke-like symptoms might have cerebrovascular disease (ischaemic or haemorrhagic) or various other non-vascular disorders. The ideal imaging modality for assessment of patients with acute stroke should accurately detect both cerebral ischaemia and intracranial haemorrhage, and discriminate cerebrovascular causes from other causes. CT is the most common imaging modality used to assess patients with suspected stroke. This method is widely available, fast, easy, and less expensive than MRI. However, although CT is sensitive to acute intracranial haemorrhage, it is not sensitive to acute ischaemic stroke. Studies suggest that CT is insufficiently sensitive for the diagnosis of acute ischaemia, is subject to substantial inter-rater variability in interpretation, and might not be better than MRI for detection of acute intracranial haemorrhage.[1–4]

MRI offers advantages for the assessment of acute stroke. Changes of acute ischaemic injury are detectable sooner with MRI than with CT, especially with diffusion-weighted imaging, and ischaemic stroke diagnosis with MRI has greater interobserver and intraobserver reliability than CT, even in readers with little experience.[5–8] Historical concerns that MRI is not sufficiently sensitive to detect acute intracranial haemorrhage in the earliest hours from onset have been addressed by studies that show gradient-echo MRI is as accurate as CT in patients with focal stroke symptoms within 6 h of symptom onset.[1,3] However, the relative diagnostic yield of MRI and CT for routine emergency assessment of possible stroke, irrespective of time from onset, severity of symptoms, or ultimate diagnosis (cerebrovascular or otherwise), had not been investigated. We aimed to prospectively compare CT and MRI for the detection of acute stroke in the full range of patients who present for emergency assessment of stroke-like symptoms.

Methods

Study participants and clinical diagnosis

This study was a single-site, prospective comparison of CT and MRI for the assessment of acute stroke. It took place from Sept, 30, 2000, to Feb, 25, 2002, at Suburban Hospital, a community hospital in Bethesda, Maryland, USA, in accordance with the institutional review boards of both the hospital and the National Institute of Neurological

Disorders and Stroke. A consecutive series of patients referred to the hospital's stroke team because of suspicion of acute stroke were eligible, irrespective of time from onset, symptom severity, or ultimate clinical diagnosis. The decision to use imaging was initiated by the emergency physician on suspicion of an acute stroke and before assessment by a stroke specialist. Emergency clinical assessment, including the National Institutes of Health stroke scale (NIHSS), was done by the stroke specialist according to the stroke centre routine. Assessments were typically made within an hour of one or both scans, although exact times of the clinical assessments were not routinely recorded, and the NIHSS might not have been used if the physician decided the diagnosis of stroke was unlikely. Patients were excluded from the present analysis if either CT or MRI was not done. Reasons for exclusions included contraindications to MRI, symptoms strongly suggestive of subarachnoid haemorrhage, initiation of antithrombotic or thrombolytic treatment before the completion of both scans, or inability to complete both scans in time to allow thrombolytic treatment within 3 h of the onset of symptoms. Results from a subset of these patients were previously reported in a multicentre comparison of MRI and CT for diagnosis of intracranial haemorrhage under 6 h.[3]

The order of scanning was not randomised because such a requirement would have necessitated clinically unjustifiable delays in patient assessment and management. By design, MRI was to be done before CT, and the scans were to be initiated within 120 min of each other, but patients who did not meet this requirement were not excluded from the primary analysis.

The final clinical diagnosis was that documented in the patient's hospital record during the admission by the responsible stroke-team neurologist, on the basis of all available clinical information, including acute and follow-up brain imaging and ancillary testing. Patients with imaging evidence of cerebral infarction were given a final diagnosis of ischaemic stroke even if deficits were transient. The diagnosis of transient ischaemic attack was reserved for transient deficits (less than 24 h duration) without imaging evidence of infarction.

Imaging techniques and analysis

For MRI we used a 1·5 T scanner (GE Signa, General Electric, Milwaukee, WI, USA). Only patients for whom gradient-echo imaging and diffusion-weighted imaging sequences had been completed were eligible for enrolment. Gradient-echo imaging parameters were field of view 24 cm, repetition time (TR) 800 ms, echo time (TE) 20 ms, flip angle 30°, and acquisition matrix 256×192. Diffusion imaging parameters were field of view 24 cm, TR 6000 ms, TE 72 ms, acquisition matrix 128×128, and b values of 0 and 1000 s/mm² isotropically weighted. Both sequences yielded 20 contiguous slices that were 7 mm thick axial-oblique. Although other imaging sequences were also obtained, we did not assess them. For non-contrast CT we used either a Somatom Plus scanner (Siemens, Iselin, NJ, USA) or a Lightspeed scanner (General Electric). Images were acquired in the orbitomeatal plane with 5 mm slice thickness from the skull base through the vertex.

Images were analysed by two expert neuroradiologists and two expert stroke neurologists, who were not connected with the care of patients and were unaware of all clinical information. Readers viewed the images independently, and were asked to record evidence of acute ischaemic stroke, acute haemorrhage, chronic haemorrhage, no acute stroke, or a combination of these.

Digital images were presented to readers with commercially available software that enabled readers to adjust the contrast, brightness, and size of the images. All images were devoid of patient identifiers. For MRI interpretation, readers were provided with images from the gradient-echo imaging and diffusion-weighted imaging sequences; diffusion-weighted imaging sequences included b=0, T2-weighted images. If the gradient-echo images were not interpretable because of motion artifact, readers were asked to use the b0 component of the diffusion-weighted images for haemorrhage detection. For CT interpretation, readers were provided with image sets adjusted for bone windows and conventional brain windows, and were allowed to adjust brightness and contrast on the displayed images. The CT and MRI images were randomly sorted, and pairs (CT and MRI) corresponding to each patient were presented on different days to avoid recognition of imaging findings by readers. For a case to be judged positive for the different variables of interest, the interpretation needed to be concordant for at least three of the four independent readers. The number of acute stroke diagnoses might be fewer than the sum of the subtypes if patients had both subtypes.

Statistical analysis

The primary hypothesis was that MRI is better than CT for the diagnosis of all forms of acute stroke. Secondary hypotheses were that MRI is better than CT for detection of acute ischaemic stroke, and that it is not worse than CT for detection of acute intracranial haemorrhage. We used McNemar's paired proportion test to measure the concordance between MRI and CT for each diagnosis. The hypothesis that was expected to show the smallest difference—comparison of MRI to CT for diagnosis of intracranial haemorrhage—was used to decide the target sample size. Therefore, the null hypothesis was that MRI was worse than CT for the detection of intracranial haemorrhage, and the alternative hypothesis was that MRI was not worse than CT for the detection of intracranial haemorrhage. On the assumption that MRI would be 2·5% more sensitive than CT, and that the proportion of discordant pairs would be 3·5%, with an 80% power, we decided that a sample size of 380 would be needed to reject the null hypothesis by the McNemar paired proportion test.

Sensitivity, specificity, and accuracy of blinded CT and MRI diagnosis obtained in this study were estimated in relation to final clinical diagnosis. The significance of correlated proportions was tested with the McNemar test. For this comparison, the diagnostic categories for the admission were acute stroke (acute ischaemic stroke, acute intracranial haemorrhage) or not acute stroke (including transient ischaemic attack). Logistic regression analysis was used to examine predictors of false-negative MRI outcomes.

Role of the funding source

The corresponding author is an employee of the funding source. The corresponding author had full access to all the data in the study and had final responsibility for the study design, data collection, data analysis, data interpretation, writing of the report, and decision to submit for publication.

Results

Over 18 months, 450 patients were screened and 94 were excluded—49 because of MRI contraindications (ie, electronic implants, severe patient agitation or claustrophobia, or medical instability); 34 because CT was not obtained because of failure to follow protocol or because treatment was initiated immediately after MRI; and 11 because CT was uninterpretable (ie, severe patient movement or failure to save scans). All MRIs were judged adequate for the panel of readers to make an interpretation of presence or absence of acute stroke, even if their quality was degraded by motion or other artifacts.

The study sample size was 356 patients. The median age of these patients was 76 years (range 21–100). The median time from symptom onset to MRI imaging was 367 min (range 36 min to 8 days; interquartile range 2 h 32 min to 8 h 34 min). The median time from symptom onset to CT imaging was 390 min (36 min to 8 days; 2 h 52 min to 8 h 51 min). The median difference in start time between MRI and CT imaging was 34 min earlier for MRI (236 min earlier to 212 min later; 26–41 min earlier). MRI was done before CT in 304 (85%) patients.

Table 1 shows that of the 356 patients referred because of clinically suspected stroke, acute stroke was the final clinical diagnosis for almost two-thirds. Acute stroke was detected in 185 of 356 (52%; 95% CI 47–58) with MRI and 59 of 356 (17%; 13–21) with CT. Table 2 shows that detection of all acute strokes (ischaemic or haemorrhagic) was more frequent with MRI than with CT ($p<0·0001$). The four readers unanimously agreed on the presence or absence of acute stroke in 286 cases (80%, 76–84%) with MRI and 207 (58%, 53–63%) with CT (table 3).

Ischaemic acute stroke was the final clinical diagnosis in more than half the study population. Table 1 shows that MRI detected ischaemic acute stroke in 164 of 356 patients and CT in 35 of 356. Table 2 shows similar detection rates in patients scanned within 3 h of symptom onset, acute ischaemic stroke was detected by MRI in almost half of these 90 patients, and by CT in less than a tenth. In the 131 patients scanned between 3 h and 12 h of symptom onset, acute ischaemic stroke was detected by MRI in 53 (41%; 32–49%), and by CT in 16 (12%; 7–19%).

Table 2 shows that acute intracranial haemorrhage was detected by MRI in 23 of 356 patients (6%, 4–10%) and by CT in 25 (7%, 5–10%). For the detection of all forms of intracranial haemorrhage (acute or chronic), MRI was better than CT ($p<0·0001$). When only intraparenchymal

	CT	MRI	Clinical diagnosis
Acute stroke	59 (17%, 13–21%)	185 (52%, 47–58%)	217 (61%, 56–66%)
Acute ischaemic stroke	35 (10%, 7–14%)	164 (46%, 41–51%)	190 (53%, 48–59%)
Acute intracranial haemorrhage	25 (7%, 5–10%)	23 (6%, 4–10%)	27 (8%, 5–11%)
No stroke	297 (83%, 79–87%)	171 (48%, 43–53%)	139 (39%, 34–44%)

Data are number (% of total sample, 95% CI).

Table 1: **Blinded imaging diagnosis compared to final clinical diagnosis**

		Total sample			<3 h from onset (n=90)		
		CT+	CT−	p value	CT+	CT−	p value
Acute stroke	MRI+	56	129	<0·0001	16	33	<0·0001
	MRI−	3	168		1	40	
Acute ischaemic stroke	MRI+	32	132	<0·0001	6	35	<0·0001
	MRI−	3	189		0	49	
Intracranial haemorrhage (acute or chronic)	MRI+	23	66	<0·0001	10	18	<0·0001
	MRI−	2	265		1	61	
Acute intracranial haemorrhage	MRI+	21	2	ns	9	1	ns
	MRI−	4	329		2	78	
Acute haematoma or haemorrhagic transformation	MRI+	18	2	ns	7	1	ns
	MRI−	2	334		2	80	
Any haematoma or haemorrhagic transformation (acute or chronic)	MRI+	19	13	0·002	8	3	ns
	MRI−	1	323		1	78	
Chronic intracranial haemorrhage	MRI+	0	73	<0·0001	0	22	<0·0001
	MRI−	0	283		0	68	

CT=computed tomography. MRI=magnetic resonance imaging. MRI+=positive diagnosis with MRI. MRI−=negative diagnosis with MRI. CT+=positive diagnosis with CT. CT−=negative diagnosis with CT. Data are numbers of patients. P values calculated by McNemar's paired proportion test. NS=not significant.

Table 2: **Paired proportion analysis of CT *vs* MRI for the diagnosis of stroke**

	Yes	No	CT (n)	MRI (n)
Acute stroke	0	4	168	124
	1	3	96	30
	2	2	33	17
	3	1	20	23
	4	0	39	162
Acute ischaemic stroke	0	4	193	149
	1	3	97	32
	2	2	31	11
	3	1	17	20
	4	0	18	144
Acute intracranial haemorrhage	0	4	316	309
	1	3	15	13
	2	2	0	11
	3	1	4	6
	4	0	21	17

Table 3: **Agreement between diagnoses by the four readers**

	n	Acute stroke		Acute ischaemic stroke	
		CT	MRI	CT	MRI
Sensitivity					
All	356	26% (20–32)	83% (78–88)	16% (12–23)	83% (77–88)
>12 h	135	22% (14–33)	91% (82–96)	16% (9–27)	92% (83–97)
3–12 h	131	29% (19–41)	81% (70-89)	20% (12–33)	81% (69–90)
<3 h	90	27% (17–40)	76% (64–86)	12% (5–24)	73% (59–84)
Specificity					
All	356	98% (93–99)	97% (92–99)	98% (94–99)	96% (92–99)
>12 h	135	98% (89–100)	96% (86–99)	98% (90–100)	97% (88–99)
3–12 h	131	97% (87–99)	98% (90–100)	96% (87–99)	99% (91–100)
<3 h	90	100% (85–100)	96% (79–100)	100% (89–100)	92% (78–98)

Data in parentheses are 95% CI.

Table 4: **Sensitivity and specificity of blinded imaging diagnosis by time from onset to scan**

haematoma or haemorrhagic transformation were considered (ie, aside from diagnoses of haemorrhage consisting of chronic microbleeds only) diagnosis of intracranial haemorrhage (acute or chronic) was more frequent by MRI than by CT ($p<0·002$). MRI was better for the detection of chronic haemorrhage ($p<0·0001$).

The relative sensitivity and specificity of CT and MRI were then assessed by comparison of blinded MRI and CT diagnoses with the final clinical diagnosis, as summarised in table 4. Acute stroke was the final diagnosis by treating physicians in 217 of 356 patients (61%), including acute intracranial haemorrhage in 27 (8%), and transient ischaemic attack in 50 (14%). In 89 of 356 patients (25%) the final diagnosis was not cerebrovascular disease. In 190 patients with a final clinical diagnosis of acute ischaemic stroke, the median severity by NIHSS score was 3 (range 0–37).

When compared with the final clinical diagnosis, MRI had a higher sensitivity than CT for all acute stroke and for acute ischaemic stroke ($p<0·0001$ by McNemar test). For diagnosis of acute intracranial haemorrhage, MRI had a sensitivity of 81% (95%CI 61–93%) and a specificity of 100% (98–100%), compared with 89% (70–97%) and 100% (98–100%), respectively, for CT. Relative to a final clinical diagnosis of acute stroke, MRI had an accuracy of 89% (85–92%) and CT of 54% (49–59%).

MRI was positive in 157 of 190 (83%; 77–88%) cases of acute ischaemic stroke, with a false-negative rate of 17% (12–24%). No cases of false-negative MRI were positive on CT. By stepwise multivariable logistic regression, false-negative MRI diagnoses of ischaemic stroke were associated with brainstem location (adjusted odds ratio 7·3, 95% CI 2·2–25·0), time from symptom onset to scan less than 3 h (5·8, 2·3–14·9), and NIHSS score of less than 4 (3·2, 1·3–7·9). Of the 31 ischaemic stroke patients with two or more predictors, the false-negative rate was 15 of 31 (48%; 31–67%), whereas the false-negative rate was 17 of 169 (10%; 6–16%) with either no predictor or only one. Two patients had all three predictors; both were false negatives. The treating physicians with knowledge of clinical localisation and additional imaging data had identified an acute lesion at the time of the clinical event on diffusion-weighted imaging in 23 of the 32 masked false-negative cases.

Discussion

We report that MRI is more effective than CT for the diagnosis of acute stroke in a typical patient sample. Our sample was representative of the range of patients who are likely to present with a clinical suspicion of acute stroke, including patients who ultimately proved to have a different diagnosis. Therefore, our results are directly applicable to clinical practice.

The earliest comparisons of MRI to CT in the diagnosis of acute stroke, from the early 1990s, before clinical diffusion-weighted imaging and gradient-echo imaging were routine, showed that acute infarcts were visible more frequently on MRI than on CT and that that these modalities were much the same for detection of intracranial haemorrhage.[6,7] In the mid 1990s, diffusion-weighted imaging entered the clinic and showed promise of greater sensitivity for stroke diagnosis than conventional MRI, especially in the initial hours after stroke onset, and for the detection of small lesions.[5,9] Early reports that compared diffusion-weighted imaging MRI with CT estimated sensitivities of 86–100% for diffusion-weighted imaging and 42–75% for CT, but were limited by potential biases in patient selection and image assessment.[8,10–15]

The greater overall sensitivity of MRI for acute stroke in this study is attributable to its effectiveness for detection of acute ischaemic stroke. Diagnostic rates for acute intracranial haemorrhage were much the same for MRI and CT. MRI with diffusion-weighted imaging was both more effective within the critical first 3 h and in the entire sample. Acute ischaemic stroke was diagnosed with MRI in 46% of patients but with CT in only 10%. Of the 190 patients with final clinical diagnosis of ischaemic stroke, independent, blinded assessment with MRI diagnosed ischaemic stroke in 83% of patients, and in 16% with CT. This study accords with the reported difference between MRI and CT, but our rates of imaging diagnoses were lower in both modalities than those in previous studies.[8,10–15]

In our sample, 25% of the patients with suspected acute stroke had final diagnoses other than cerebrovascular; this rate is consistent with other samples of consecutive patients who present to emergency departments with the initial diagnosis of acute stroke.[16,17] Because the accuracies of diagnostic tests are overestimated in non-representative samples,[18] we would expect that the true accuracies of MRI and CT in acute stroke in this study would be lower than those previously reported. The addition of angiographic and perfusion acquisitions to CT might have increased the accuracy of this modality and made the results more similar to those of MRI.

False-negative diffusion-weighted imaging scans in ischaemic stroke do arise. We estimated the false negatives from such MRI scans at 17%. Two of the predictors of false-negative diffusion-weighted imaging—brainstem location and NIHSS of less than 4—could relate to small lesions that escape visual detection, especially in locations such as the brainstem, in which they might be difficult to distinguish from the hyperintensity of incompletely suppressed anisotropic diffusion or susceptibility artifacts. The practitioner must be cognisant of the possibility of false negatives with diffusion-weighted imaging for ischaemic stroke and note the presence of clinical factors that predispose to such stroke.

These results accord with our previous finding that MRI might be as accurate as CT for diagnosis of intracranial haemorrhage.[3] This expanded sample showed that MRI was not worse than CT for the detection of acute intracranial haemorrhage. These results are also consistent with previous reports that MRI can accurately detect acute intracranial haemorrhage.[1,7,19–23] Thus, clinicians who use MRI as the sole imaging modality in acute stroke can be assured that a negative MRI excludes acute intracranial haemorrhage as effectively as does a negative CT. Since MRI was done before CT in most patients in our study (77% of cases of intracranial haemorrhage), the MRI signal changes associated with intracranial haemorrhage could have been less conspicuous than they would have been at a later stage. Nevertheless, the potential time bias did not seem to affect the rate of detection of intracranial haemorrhage by MRI in this cohort.

In this study neither MRI nor CT achieved 100% sensitivity for the diagnosis of acute intracranial haemorrhage. When compared with the final clinical diagnosis there were four cases of clinically confirmed acute intracranial haemorrhage that were misdiagnosed by the readers on MRI. In two cases readers erroneously classified acute haemorrhages as chronic; in another (in which the gradient-echo imaging scan was not available) readers missed an acute intracranial haemorrhage in their interpretation of the diffusion-weighted imaging MRI; and in a fourth case, a left frontal acute intracranial haemorrhage was not diagnosed by the readers. When detection by CT images was compared with the final clinical diagnosis there were three false-negative cases of acute intracranial haemorrhage: a subdural haematoma, a haemorrhagic metastasis, and a temporal lobe haematoma were not diagnosed by the readers. Previous studies have also noted that cases of acute haemorrhagic transformation could be seen on gradient-echo imaging but not on CT.[3]

Although CT scanning has been the criterion that is standard for diagnosis of acute stroke, our study shows that use of CT is no longer justifiable on the basis of diagnostic accuracy alone. Logistical and financial arguments in favour of CT as the preferred emergency test can be made—non-contrast CT is generally more accessible for emergency use, even in facilities at which MRI is available, and the fixed and variable costs of CT scanning are less than for the costs of MRI scanning. Would the improvement in diagnostic accuracy offered by MRI enhance patient outcomes and cost-effectiveness enough to justify the necessary increases in expense and effort? A comparison of immediate CT with delayed CT for acute stroke showed that correct early diagnosis by immediate CT scanning increased independent survival, informed subsequent treatment and management decisions, reduced costs, and increased quality-adjusted life-years.[24] A similar analysis, comparing immediate CT with immediate MRI, would help to quantify the potential effect of increased early diagnostic accuracy of MRI on health-care costs and quality of stroke outcomes. Since immediate MRI allows more accurate diagnosis than immediate CT, it might increase the cost-effectiveness of stroke care, since definitive treatments and secondary prevention could be initiated sooner than with CT alone.

A potential bias was introduced by our decision not to randomise the order of scanning. However, since abnormalities become more conspicuous over time with both MRI and CT, the probability of detection of stroke was biased in favour of CT, which was done after MRI in our study. Therefore this bias cannot account for our results.

The selection bias against patients who were judged too medically unstable to undergo MRI probably eliminated severe strokes that would be readily detectable on imaging, and thus falsely decreased the sensitivity to some degree. Our study included the typical acute stroke population, and therefore skewed the distribution towards mild cases. This feature of our sample might explain why we recorded lower CT sensitivity and a greater difference between CT and MRI than studies that excluded cases less severe than a minimum criterion according to an established stroke diagnosis.[8] This difference between our findings and other studies persisted at later times from onset.

Although the need for urgent management of patients with transient ischaemic attacks and mild stroke has been increasingly recognised,[25,26] accurate diagnosis on the basis of clinical presentation and CT scanning can be especially difficult in these patients. MRI is more sensitive than CT for severe stroke, but the difference might not be clinically significant if a systematic method for CT reading is used.[27] Nevertheless, because mild stroke and transient ischaemic attack make up most stroke admissions to a general hospital emergency department, our findings are directly applicable to real-world practice.

MRI can be used as the sole modality for the emergency imaging of patients with suspected acute stroke, whether ischaemic or haemorrhagic. The high diagnostic accuracy of MRI was the same for scans within the first 3 h as it was for the entire sample, and thus is relevant to patients who might be eligible for standard thrombolytic treatment of stroke. Many stroke centres use MRI as the basis of

thrombolytic treatment decisions,[28] and where MRI is immediately available for emergency stroke diagnosis, initiation of thrombolytic treatment will not be substantially delayed.[29]

Since imaging studies in acute stroke are usually interpreted by non-specialists, the imaging modality with the highest sensitivity and the highest intra-rater and inter-rater reliability for diagnosis of ischaemic stroke by non-specialists—MRI—should be used.[8] Because MRI is more effective for detection of acute ischaemia, and can detect acute and chronic haemorrhage, it should be the preferred test for accurate diagnosis of patients with suspected acute stroke.

Contributors

All authors participated in the data analysis and reporting stage of this manuscript, and have seen and approved the final version.

Conflict of interest statement

We declare that we have no conflict of interest.

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