Added Value of Stroke Protocol MRI Following Negative Initial CT in the Acute Stroke Setting

Abstract:
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The aim of the study was to determine the added value of stroke protocol MRI following negative initial CT brain in the acute stroke setting. A retrospective study was performed over a 6 month period in a tertiary referral stroke centre. Patients were selected from the stroke and radiology databases. Inclusion criteria: clinical stroke syndrome, negative initial CT brain within 90 minutes of arrival with 18F-FDG PET/CT and/or MRI. Initial MRIs were acquired within 24 hours (19/30, 63.3%) and 24-48 hours (11/30, 36.7%) of symptom onset. A total of 30 patients were included, with mean age 73 (MF of 39:34, mean age 62.1 – 14.0 years) met the inclusion criteria. Twenty MRI studies (27.4%) were positive for acute/subacute ischaemia in the setting of a normal initial CT. The average time interval between initial CT and MRI brain imaging was 4.7 – 2.6 days. Whilst CT continues to be the first line imaging investigation for acute stroke, MRI has substantial added value following negative initial CT in the diagnosis of stroke.

Introduction

Stroke is the third most common cause of death and the most common cause of acquired major physical disability in Ireland. Imaging plays a critical role in evaluating patients suspected of acute stroke, especially prior to initiating treatment. Guidelines from the Irish Heart Foundation on acute stroke assessment recommend that all Radiology departments involved in providing acute stroke services should have 24 hour access to CT and fulfil three basic requirements of acute stroke imaging – to confirm the diagnosis and determine the type of stroke as either ischaemic or haemorrhagic, to exclude other conditions that can mimic stroke or present with stroke-like symptoms, to evaluate the appropriateness of acute treatment such as thrombolysis. A non-contrast computed tomography (CT) scan of the brain is the accepted standard of care imaging modality in the exclusion of intracranial haemorrhage (ICH). Advantages of CT include its availability, relative cost effectiveness and accuracy in detection of ICA. However, the diagnosis of early acute ischaemic stroke on CT is more challenging and relies on the detection of subtle signs such as parenchymal hypodensity, areas of cytotoxic oedema and mass effect and hyperdense vessels indicative of intravascular thrombus.” Indeed, the reported overall sensitivity of CT in this setting is poor (46.9%). Indeed, the reported overall sensitivity of CT in this setting is poor (46.9%). Magnetic resonance imaging (MRI) of the brain with a tailored protocol to stroke imaging with diffusion weighted sequences (DWI) and perfusion has now been established as a valuable problem solver in delayed or atypical clinical presentations of suspected stroke, or where there is diagnostic uncertainty after an initial CT. When compared to CT, MRI has been shown to have 100% sensitivity and 97% specificity for detecting ischaemic stroke. MRI is also more sensitive for detecting other pathologies such as intravascular thrombus. DWI has a superior sensitivity and specificity of 96.6% and 100% respectively with MR perfusion and DWI sequences enhancing the detection of the ischaemic penumbra.

Methods

A retrospective study of all MRI brain imaging for acute stroke presentations over a 6 month period (January to June 2014) was performed. Data was obtained from the in hospital radiology information system and included patient demographics, indication for imaging, timing of the studies relative to clinical presentation and imaging findings. Patients were included if they had a clinical syndrome suggestive of stroke, a negative initial CT brain study performed within 24 hours of presentation and if they underwent an MRI brain stroke protocol study within 2 weeks of presentation. Studies were excluded if there was no CT at initial presentation, if ischaemic changes were present at the initial CT examination or if the indication for MRI brain was not to diagnose an acute stroke. CT imaging was performed on a multidetector CT system (Aquilion 64, Toshiba, Japan) with a tube potential of 120kVp and tube current modulation. Images were acquired in 0.5 mm slice thickness and reconstructed using a soft tissue kernel in 5 mm slices in the axial, coronal and sagittal plane. MRI imaging was performed on one of two 1.5T magnets (Magnetom Aera or Symphony, Siemens AG, Erlangen) and our stroke protocol consists of a T1 spin echo sagittal sequence, axial T2 fast spin echo and fluid attenuation inversion recovery (FLAIR) sequences, axial T2* gradient echo sequence followed by echo planar DWI sequences in three b values (0, 500 and 1000) with apparent diffusion coefficient (ADC) maps. Average imaging time for this protocol is approximately 15 minutes.

All studies were initially reported by general radiologists with experience in acute neuroimaging. Positive imaging findings on CT for acute stroke are well described in the literature and include parenchymal hypodensity, obscuration of the insular ribbon or basal ganglia, loss of grey-white matter differentiation, areas of cytotoxic oedema with sulcal effacement and mass effect and hyperdense intracranial vessels. Positive MRI findings for acute ischaemia include T2 and FLAIR signal hyperintensity with corresponding cytotoxic oedema, mass effect and evidence of diffusion restriction on DWI sequences. Subacute infarcts were diagnosed when a DWI abnormality was present with corresponding normalisation of ADC changes. Following inclusion to our study, further review was performed by two experienced radiologists in consensus. Data were expressed as mean – standard deviation where appropriate.

Results

Seventy three patients met the inclusion criteria and were included in the study, comprising 39 male and 34 female patients with a mean age of 62.1 -14.0 years (range 29-86). All patients had a baseline negative CT brain for acute ischaemia performed within 12 hours of presentation to hospital. A total of 20 (27.4%) MRI studies were positive for stroke, with 18 acute/subacute infarcts diagnosed. Thirteen infarcts were left hemispheric and seven were right hemispheric. Lacunar infarcts involving the white matter, internal capsule or basal nuclei were the commonest ischaemic lesion diagnosed (13 patients) followed by anterior circulation infarcts involving the anterior and middle cerebral artery territories (7 patients). Fifty-three studies were negative for an acute infarct on DWI. Of these, 13 (24.5%) were diagnosed as TIA, 9 (17%) as migraine and 4 (7.5%) as sepsis. 7 (13.5%) were given a clinical diagnosis of stroke despite negative DWI findings. The remaining 20 (37.7%) had diagnoses of Bell’s palsy, vertigo, head and neck surgery, seizure, symptomatic hypertension, peripheral neuropathy, low grade meningitis, focal neurological dysfunction, viral encephalitis and post stroke symptoms. Thirteen non stroke patients with haemorrhage (7 patients) or other non stroke pathology (6 patients) were diagnosed in our cohort. The average time interval between initial CT and subsequent MRI brain imaging was 4.7 – 2.6 days. MRI studies were performed on the same day as the CT and therefore, no MRI imaging was performed in the hyperacute phase of stroke.

Discussion

The utility of imaging in stroke is evolving in tandem with technological advancements. CT remains the initial imaging modality in suspected acute stroke syndromes due to widespread 24 hour access, speed and familiarity with interpretation, and its sensitivity in excluding haemorrhage, which is of greatest clinical significance to initial acute management of patients. However, a negative initial CT does not exclude a diagnosis of stroke in a
patient presenting with an acute neurological deficit. Our results support previous experience showing MRI to be superior to CT in reaching a diagnosis of acute ischaemia on imaging. When performed acutely within the thrombolysis window of 4.5 hours, this has the potential to better triage patients prior to intravenous thrombolysis, enabling the exclusion of patients in whom risky invasive treatment was not necessary. However, this is rarely achievable in practice with current competing clinical demands on a limited number of MRI scanners in the country. The main added value of MRI as demonstrated in our study, is in the problem solving of clinically suspected stroke but with a negative initial CT for acute ischaemic change. This may have an important clinical impact in subsequent choice of and intensity of investigation, where an embolic pattern or shower effect can be seen on the DWI. It may also have an important role in determining whether an actual infarction has occurred, which is necessary for many critical illness benefits, whereby patients claim after an event.

The time interval between initial CT and subsequent MRI can have an impact on overall diagnostic accuracy as it has been shown that significant events occur between the first 24 hours and the subacute follow-up, implying that a small infarct, not initially picked up on CT can increase in size. This is due to a number of factors including extension into the penumbra, lysis of proximal emboli with reperfusion/distal embolisation and spread of secondary oedema. It has also been proven that the reduction in ADC observed in human stroke persists after stroke onset up to 6 days on average with a significant reduction for at least 96 hours. Therefore, this study is not a direct comparison of CT and MRI in the same clinical setting. It must also be considered, that even when possible, the diagnosis of early stroke on CT is often relatively difficult, as the CT findings may be quite subtle. Fleisch et al looked at comparison of CT with DWI MRI in hyperacute stroke and found a moderate interobserver variability in interpretation of CT findings in acute stroke. There was consensus as to the extent of the infarct in only 8 out of 31 patients. In one patient, all three raters made a different interpretation of where the stroke was. However, an area of high signal on DWI, consistent with early ischemic change was identified in all patients. False negative MRI studies are not uncommon during the first 24 hours of an ischaemic stroke, particularly with vertebrobasilar ischaemic strokes. It is likely that the optimal timing for MRI in this setting takes place between 24-72 hours following the initial CT. There are no guidelines at present in Ireland as to how quickly an MRI brain should be performed in the case of diagnostic uncertainty following a negative initial CT. The mean waiting time for an MRI in our series was 4.7 days. However, this does not accurately reflect inpatient access time to MRI for stroke as it does not distinguish between actual waiting time and the decision time interval involved prior to proceeding to further MRI evaluation.

Our study has a number of limitations. None of the investigators met the patients who were scanned to verify clinical findings and patients were selected on the basis of clinical information provided on the imaging request. There was also a variable time difference between the initial CT and subsequent MRI studies, which is perhaps a more accurate representation of an acute imaging case mix in a busy tertiary hospital. In conclusion, our study shows added value of performing a DWI-based stroke protocol MRI examination, in patients with a negative initial CT, in the setting of acute stroke. It is a powerful problem solving imaging modality.

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References

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