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LETTERS

Acute Cerebral Ischemia: CT and MR Findings

It has been reported in two recent papers (1, 2) that magnetic resonance (MR) imaging is more sensitive than computed tomography (CT) in the detection of acute cerebral ischemia.

We believe this is not entirely true, at least concerning the early phase of ischemic stroke (within 4 hours from the onset of symptoms). It is our conviction that the earlier the recognition of initial parenchymal injury the better, considering the particular therapeutic advantages this may imply.

In one of the above mentioned papers (1), MR and CT have been compared, yet the time interval between stroke and CT was 8 hours; MR was performed on average of 4 hours later, which might be a source of bias in favor of MR.

In the other paper (2), only MR data are reported; no distinction is made as to the site of the lesions, whether infra- or supratentorial. Among the patients examined within 4 hours of the stroke, only one out of 11 presented signal abnormalities on T2/WI and six presented morphologic changes on T1/WI. Such morphologic changes can also be documented by CT, which in addition would show cytotoxic edema as loss of distinction between white and gray matter and/or slight hypodensity involving cortex and deep structures, at least in the supratentorial regions (3). The usefulness of arterial enhancement, as reported by Yuh et al (2), needs further evaluation.

According to our data, CT is able to detect the presence of initial parenchymal injury within 4 hours of ictus. We do not feel that the data reported in the two papers mentioned above prove the superiority of MR over CT in hyperacute cerebrovascular ischemia.

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Reply

We appreciate the comments of Dr Bozzao and his coauthors and agree that our data do not prove the superiority of MR over CT in detecting hyperacute cerebrovascular ischemia. Because many papers (cited in our article) have already reported that MR is more sensitive than CT in detecting cerebral ischemia, the purpose of our study was to investigate the early MR findings and their temporal progression in acute stroke involving all vascular territories.

Although Bozzao et al (1) reported that subtle changes can occur within the first 4 hours, we have seen patients with normal CT examinations prior to 4 hours when MR was positive for brain ischemia. Abnormal MR findings in our four patients included absence of flow void, subtle mass effect, and/or abnormal vascular or parenchymal enhancement and were the only evidence of brain ischemia. The CT findings reported by Bozzao et al (1) are certainly interesting. It would be of value to know how they conducted their study (prospectively or blinded to the angiographic results) and analyzed their data (69.4% of their patients were positive on CT within 4 hours) and especially how they determined their false-positive rate.

We agree with previous reports that suggest MR may have the potential to be more sensitive than CT in detecting brain ischemia for the following reasons. There are four factors that may affect the detection of brain ischemia by CT or MR examinations: vascular flow abnormalities, mass effect, parenchymal edema, and parenchymal enhancement. As reported by us and others, vascular flow abnormalities, including absence of flow void or abnormal arterial enhancement, are the most reliable findings in hyperacute stroke (2–5). Because vascular flow abnormalities demonstrated by MR are based on kinetic phenomena, they can be detected immediately after occlusion (hyperacute ischemia). In spite of recent reports of hyperdense vascular signs (6–8), CT is less sensitive than MR in the detection of vascular flow abnormalities mostly because of bony artifact and relatively poor contrast between blood vessels and their surrounding structures. In addition, arterial enhancement detected by MR during brain ischemia can be caused by slow blood flow alone without complete intravascular thrombus (CT hyperdense sign), and the presence of arterial enhancement is a better indicator of brain ischemia and predictor of clinical outcome than angiographic evidence of occlusion or stenosis (9).

Mass effect associated with acute stroke can sometimes be demonstrated by CT in early brain ischemia. With its multiplanar ability and absence of bony artifact, MR has advantages over CT in detecting mass effect, especially in those lesions that are small and/or located next to bony structures. With regard to changes in brain water (edema), MR is well known to be much more sensitive in depicting

subtle tissue water changes than CT. The CT findings reported by Bozzao et al are subtle and may be more obvious on MR examinations. Finally, we have seen parenchymal enhancement demonstrated by MR in silent brain ischemia without mass effect or T2 signal changes in many patients, including those with normal carotid balloon test occlusion (10).

Although we did not compare MR and CT findings in our initial paper, we and others believe that MR is more sensitive than CT in the detection of early acute stroke. This is probably related to the inherent advantages of MR, including multiplanar ability, increased sensitivity to subtle tissue water changes, and improved detection of vascular abnormalities and early parenchymal enhancement.

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Reply

Dr Bozzao and colleagues have raised several pertinent questions related to our comparison of CT and MR imaging for the diagnosis of acute cerebral infarction. As reported in our paper, there was an average delay of 4 hours between the initial CT scan and the initial MR scan. We agree that this may result in a bias in favor of MR. However, other clinical reports, including that of Dr Yuh et al (1) and numerous animal studies (2, 3) would suggest that MR scans routinely become positive by 6 hours after the onset of acute ischemia. This would indirectly suggest that our MR studies would have been positive if they had been performed on the average of 4 hours earlier, at the same time as CT. However, we know of no reported documentation of this presumption. Dr Bozzao also suggests, on the basis of his previous work (4), that CT is more sensitive to early ischemia than our results indicate.

As noted in our paper, our CT sensitivity percentage of 58% is less than some earlier reports (5, 6). However, none of these earlier reports were prospective studies utilizing multiple, clinically blinded readers and none were statistically analyzed for sensitivity and specificity, taking into account interobserver variability. We believe that our statistics reasonably reflect clinical practice, particularly when specificity is taken into account. While sensitivity could be increased by "closer" reading of the scans, the false positive rate would increase and specificity decrease. When considering the future management of patients, which may include therapies with significant patient risks, not only is sensitivity important but specificity as well.

The CT changes reported by Dr Bozzao et al (4) are often quite subtle, as can be seen in Figures 3 and 4 of their article. Normal variation and minor motion artifacts can simulate these pathological findings. The difficulty in correctly diagnosing acute stroke on CT is reflected by the greater interobserver variability in our study. On the other hand, the signal changes on MR are more obvious and associated with less interobserver variability. We do believe that MR is more sensitive and specific than CT in the diagnosis of acute stroke.

We agree with Dr Bozzao et al that the earliest possible recognition of parenchymal ischemia is crucial to potential therapeutic success. We are concerned about how early the MR signal changes may occur. Based upon animal work, Dr Yuh's report and other anecdotal clinical reports, we suspect that initial MR signal changes may not occur within the first 2 to 4 hours after ictus. Assuming improvement in public health education and medical triage, this temporal limitation of MR (and CT) could become increasingly important. Other imaging studies with even greater sensitivity to acute ischemia, such as diffusion or perfusion MR imaging, MR spectroscopy, PET, or SPECT, might become necessary.

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