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Role of Imaging in Acute Ischemic Stroke

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Rapid multimodal imaging is essential in the workup and management of acute ischemic stroke. Early parenchymal findings on noncontrast computed tomography or standard magnetic resonance imaging are used to triage patients for intravenous thrombolysis and to provide insight on prognosis. In the wake of recent endovascular stroke trials, advanced techniques including perfusion imaging and noninvasive vascular imaging are becoming important tools to guide potential endovascular treatment or expand therapy windows. Advanced imaging is also important in pediatric ischemic stroke which requires a slightly different workflow and treatment approach. Here, we will discuss key imaging findings in acute ischemic stroke, as well as the present and future of neuroimaging in light of recent and ongoing clinical trials.
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Introduction

The critical component of acute ischemic stroke (AIS) management is early revascularization of at-risk but potentially salvageable brain tissue, which can be viable for a period of time owing to collateral perfusion.[1] The role of imaging in AIS is therefore to identify affected brain parenchyma and to delineate any areas of potentially salvageable tissue with the goal of early intervention and reperfusion.

With the success of recent endovascular therapy trials, there has been a paradigm shift from use of intravenous tissue-type plasminogen activator (IV tPA) alone to the addition of early endovascular therapy in appropriately selected patients. IV tPA alone is generally better for reperfusion of small distal vessel occlusions than large proximal occlusions.[2,3] Rapid multimodal imaging is therefore critically important to identify patients who may benefit most from endovascular therapy. The use of various rapid imaging techniques has been an integral component of recent major stroke trials and are detailed in this review.[4-7] With the use of advanced computed tomography (CT) imaging tools, the time taken from stroke onset to first reperfusion has not substantially increased in some trials.[8] However, there are a few additional recent trials which have used magnetic resonance imaging (MRI) and perfusion imaging to identify patients eligible for endovascular therapy or thrombectomy up to 6-24 hours after stroke symptom onset.[9,10] Another important area of research is the use of MRI to identify eligible candidates for thrombolysis when symptom onset is unknown.[11]

Here, we discuss the parenchymal imaging findings of AIS with a focus on multimodal CT and MRI including angiographic and perfusion imaging. We will also describe how multimodal imaging can be incorporated into the existing stroke imaging workflow and briefly discuss imaging in pediatric ischemic stroke.

CT Parenchymal Findings

Noncontrast enhanced CT (NCCT) remains a first-line imaging technique in the evaluation of suspected AIS. It is used to rapidly assess for any mimics of acute stroke and to identify evidence of an intracerebral hemorrhage which would contraindicate IV tPA therapy.[12,13]

Parenchymal findings of AIS can be detected very early with NCCT, with abnormalities found in up to 75% of patients with

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middle cerebral artery (MCA) stroke within 3 hours.[14] When AIS occurs there is an increase in intracellular water, or cytotoxic edema, in the affected parenchyma. This manifests on NCCT as decreased attenuation of tissue, loss of gray-white matter differentiation, and focal swelling which can lead to effacement of the sulci or mass effect (Fig. 1A and B). In the setting of MCA territory infarct, the loss of tissue attenuation can be detected early in the basal ganglia, particularly in the lentiform nucleus. Another early sign of MCA territory infarct is loss of gray-white differentiation at the insular cortex which is known as the "insular ribbon sign." These findings can be subtle in the early time windows and it is important to use narrow window settings to detect them.[13] NCCT can also allow direct visualization of a hyperdense thrombus in an occluded artery (Fig. 1C), known as the "dense vessel sign." In the setting of low hematocrit or the presence of imaging artifact, this sign may not be detected and thus it is not very sensitive. It is, however, very specific when mimics such as arterial calcifications are excluded.[13,14]

An objective way to evaluate the extent of ischemic changes and estimate patient prognosis is the widely used Alberta Stroke Program Early CT Scale system (ASPECTS), which was initially proposed in 2000. The ASPECTS scale is a negative ordinal scale which assigns an equally weighted score of 1-10 to different MCA territory regions of interest on NCCT imaging. These regions include the caudate nucleus (C), insular ribbon (I), internal capsule (IC), lentiform nucleus (L), and 6 cortical MCA territory regions divided into superior and inferior anterior, middle, and posterior regions (M1-M6). These regions are assessed for early ischemic changes, which are defined as hypoattenuation or loss of gray-white differentiation. Isolated cerebral swelling without associated hypoattenuation is not considered an early ischemic changes because it may be seen with potentially viable parenchyma.[15]

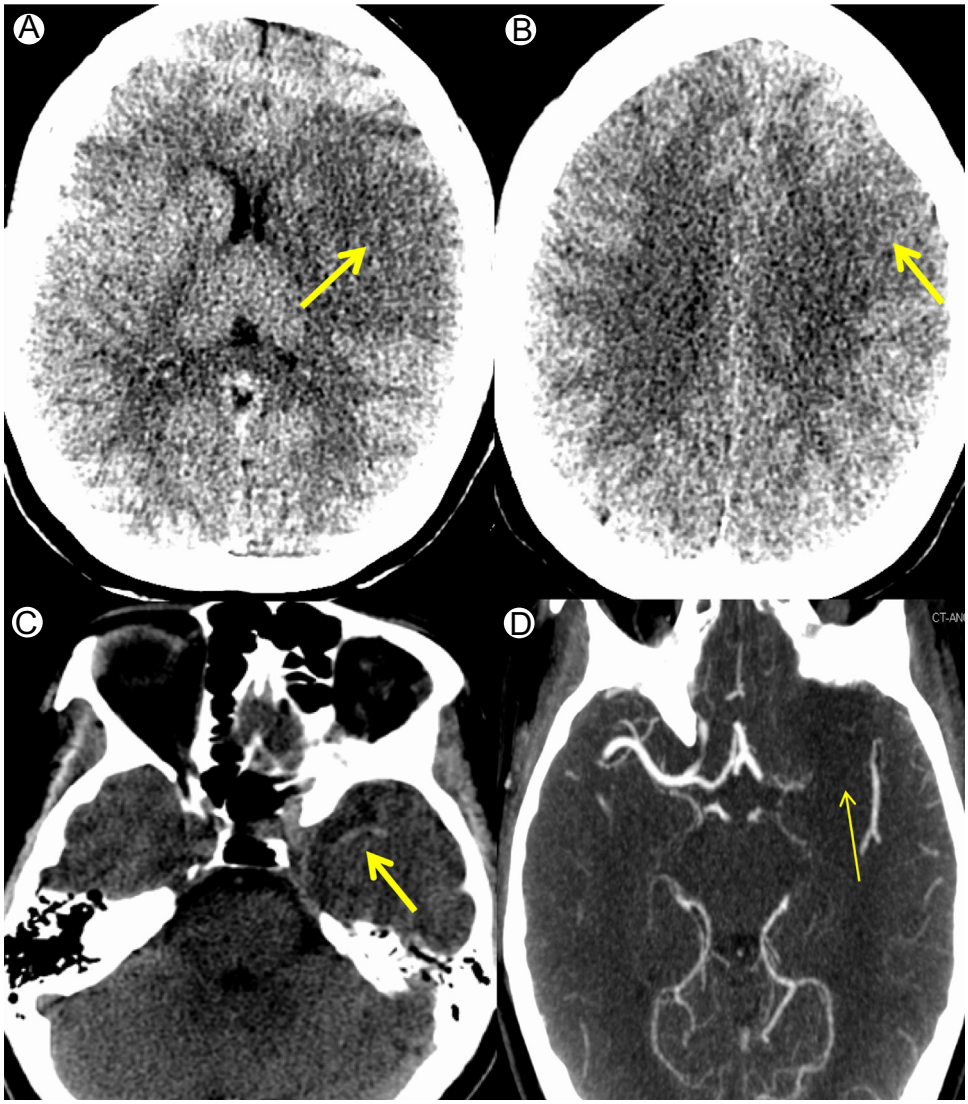

Figure 1 CT parenchymal and vascular findings in acute stroke. A 45-year-old male with right-sided weakness, 5 hours since last known prior. Axial noncontrast CT images (A-C) demonstrate hypoattenuation and loss of gray-white differentiation in the left MCA distribution with involvement of the internal capsule, lentiform nuclei, and insular cortex (arrows on A and B). There is a left "hyperdense vessel" sign (bold arrow on C) indicative of left M1 thrombus. Axial CT angiography image (D) confirmed the occlusive thrombus (arrow). (Color version of figure is available online.)