The Adult Patient with Acute Neurologic Deficit
An Update on Imaging Trends

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KEYWORDS

• Stroke • CT • CT angiography • MR imaging • Intravenous thrombolysis
• Intraarterial thrombectomy • Endovascular thrombectemy

KEY POINTS

- Abrupt onset of a focal neurologic deficit typically defines the clinical syndrome of stroke.
- Neuroimaging has an essential role in differentiating ischemic from hemorrhagic stroke and guiding patient selection for intravenous thrombolysis (IVT) and intra-arterial thrombectomy (IAT).
- Obtaining advanced imaging (CTA, DWI) for patient selection for IAT should never delay the administration of IVT when the patient is otherwise eligible, up to 4.5 hours post-ictus.
- The recent DAWN and DEFUSE 3 trial results showed a strong benefit of IAT when administered within 24-hours post-ictus, in appropriately selected patients using advanced imaging.

INTRODUCTION

Abrupt onset of a focal neurologic deficit typically defines the clinical syndrome of stroke, although stroke mimics—which include but are not limited to seizure (20%), syncope (10%–20%), sepsis or hypo/hyperglycemia (14%), subdural hematoma or tumor (10%–12%), somatization/anxiety and hyperventilation (5%–10%), transient global amnesia, and complex migraine (30%–35%)—have been estimated to occur as often as 10 times more frequently as ischemic or hemorrhagic stroke.[1] Stroke reflects neuronal dysfunction secondary to hypo-oxygenation and can be associated with temporary (transient ischemic attack) or permanent (infarction) neuronal injury. Because only a small number (<5%) of patients with signs & symptoms of acute stroke present to an emergency department within the 3 to 4.5-hour time window for treatment by intravenous "clot busting" tissue plasminogen activator (IV-rPA), timely advanced imaging with CT, CT angiography (CTA), and, whenever possible, diffusion-weighted MR imaging (DWI-MR) remains essential to patient assessment - even in patients with transient ischemic attack or rapid clinical improvement (ie, "too good to treat"), to identify treatable causes of ischemia and prevent a stroke (eg, severe internal carotid artery stenosis or dissection). Unenhanced CT (noncontrast CT) is required for all stroke patients to exclude hemorrhage. Advanced imaging requires, at minimum, CT angiography (CTA), to both identify a proximal large vessel occlusion (LVO) and to access collaterals. To the greatest extent possible, diffusion-weighted MR imaging (DWI) should be performed as the most accurate modality for determining irreversibly infarcted tissue core; additional CT or MR perfusion imaging (MRP) is increasingly obtained at many centers. Recent prospective clinical trials published in *The New England Journal of Medicine* (*NEJM*) and other high-impact journals, have not only helped define the central role of advanced neuroimaging modalities—CTA, CTA collaterals,

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CT perfusion (CTP), MR imaging–DWI, MR imaging–fluid-attenuated inversion recovery (FLAIR), and magnetic resonance angiography (MRA)—in patient selection for intra-arterial thrombectomy (IAT) treatment but also helped make possible extending the time window for this treatment up to 24 hours post-ictus, as recently demonstrated in the DAWN and DEFUSE 3 trials.[2,3]

Core is brain tissue that has been irreversibly infarcted at presentation; *penumbra* is markedly hypoperfused at-risk tissue that has a high probability of infarction in the absence of timely reperfusion. Most true stroke syndromes are ischemic, with a majority due to an intracranial, circle of Willis LVO from an embolus (approximately 85%) and with only a small percentage attributable to global cerebral hypoperfusion (so called low-flow or border-zone strokes); global anoxic injury, from near-drowning, carbon monoxide poisoning, or other causes of suffocation, is also less common. Approximately 10% of strokes are hemorrhagic due to intracerebral hemorrhage, with 3% due to subarachnoid hemorrhage.[4,5]

It is estimated that 795,000 persons have a stroke each year in the United States, causing 140,000 deaths.[4,5] That said, stroke has moved from the third leading cause of death in 2007 to the fifth in 2017.[4–6] Although major recent advances in neuroimaging and stroke treatment have contributed to a decrease in mortality, stroke remains the leading cause of serious long-term disability in the United States and costs the health care system an estimated $34 billion each year.[4]

Neuroimaging has a central role in the differential diagnosis of patients with suspected stroke, by differentiating ischemic from hemorrhagic stroke, identifying other causes of acute neurologic deficit (ie, stroke mimics), and helping in patient selection for IAT. An estimated 9% to 30% of patients with suspected stroke—and 3% to 17% of patients treated with IV-tPA—have stroke mimics.[7–16] Current treatment options for acute embolic stroke include IV-tPA, IAT, or a combination of both. Therapeutic options for intracerebral hemorrhage, subarachnoid hemorrhage, and stroke mimics vary by the etiology.

ETIOLOGY AND TIMELINE OF ISCHEMIC STROKE

Ischemic strokes are divided into 5 subtypes based on etiology: large-artery atherosclerosis (most commonly from the cervical carotid arteries), cardioembolism (secondary to clot formation in the heart), small-vessel occlusion (lacunar infarct, which is <20 mm diameter), stroke of other determined etiology (such as dissection, nonatherosclerotic vasculopathies, or global hypoperfusion), and stroke of undetermined etiology.[17]

The most common causes of the stroke vary in different age groups. Carotid disease (large artery) and atrial fibrillation (cardioembolism) are the most common causes of acute ischemic stroke in patients over age 40. Hypertensive and coronary heart diseases are the most common underlying disorders in patients with atrial fibrillation. Atrial fibrillation is highly associated with left atrium enlargement with 39% increase in risk per 5-mm increment.[18] Therefore, in an older patient with an enlarged left atrium, the stroke may be due to atrial fibrillation. The most common causes of ischemic stroke in patients below age 40 include dissection, nonatherosclerotic vasculopathies, and paradoxic stroke in conditions, such as a patent foramen ovale and arteriovenous shunts in the lungs.

Clinical history can provide important clues in determining the cause of stroke. For example, dissection should be considered in young patients (typically age <40) after yoga, weight lifting, or chiropractic manipulation, whereas paradoxic embolus from deep vein thrombosis through a patent foramen ovale is at the top of the differential diagnosis list as the cause of acute ischemic stroke in a pilot or a long-distance traveler presenting with abrupt onset of new neurologic deficit.[19,20]

Ischemic stroke is loosely classified as hyperacute, acute, subacute, and chronic, based on the symptom onset time. Typically, the hyperacute phase is within 6 hours to 8 hours of stroke onset, when patients are potentially eligible for various well-established reperfusion treatments (ie, IV-tPA and/or IAT). Acute stroke is considered stroke of less than 24 hours' duration, with the subacute and chronic stages ranging from 1 day to 1 month and greater than 1 month, respectively. Part of the problem with these loose definitions, however, is that stroke progression and infarct growth vary widely from patient to patient, largely attributable to the quality of the intracranial collateral blood flow around a site of proximal LVO. One of the overarching goals of patient selection using advanced imaging is to replace the concept of making treatment decisions based on an arbitrary clock time with the concept of making treatment decisions based on stroke physiology, as determined by the concurrent neuroimaging findings at the time of triage.

ROLE OF NEUROIMAGING IN DIAGNOSIS AND MANAGEMENT OF PATIENTS WITH ACUTE ISCHEMIC STROKE

Neuroimaging has 4 critical roles in the assessment of patients with an acute ischemic