Chapter 6
Acute Ischemic Stroke

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6.1 Introduction

Stroke presentations are varied and complex. They are dependent upon the function of brain tissue that is affected or at risk. At the stroke onset, symptoms are typically at maximum severity. This may reflect a stroke that is caused by an embolus that abruptly occludes a cerebral arterial branch. Presentations that fluctuate or slowly progress may be dependent on perfusion, possibly from reduced blood flow in a preexisting or new fixed vessel stenosis.

It is beyond the scope of this chapter to detail the pathophysiology of all stroke types as this chapter is focused on the diagnosis and treatment of acute ischemic stroke. However, it is important to appreciate that for patients who experience an acute ischemic stroke, disruption of cerebral blood flow due to an obstruction of a blood vessel initiates a complex series of circulatory and metabolic events referred to as the ischemic cascade.

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J.L. White, K.N. Sheth (eds.), *Neurocritical Care for the Advanced Practice Clinician*, DOI 10.1007/978-3-319-48669-7_6

The ischemic cascade occurs when blood flow in the brain measures less than 25 ml/min/100g. At this point, neurons are no longer able to maintain aerobic respiration; this switch to anaerobic metabolism generates large amounts of lactic acid and glutamate, changing the tissue pH and rendering cells incapable of producing sufficient quantities of adenosine triphosphate (ATP) to fuel cell depolarization processes [1]. Electrolyte balances begin to fail and the cells cease to function. Cell death at the site of vessel occlusion is referred to as the (*core infarct*). The surrounding area of affected brain tissue in which blood flow has been reduced is referred to as the *ischemic penumbra*. In selected patients, it is this stunned brain tissue that is deemed salvageable with early intervention, such as with thrombolysis (administration of intravenous tissue plasminogen activator or IV alteplase) [2] and/or with mechanical thrombolysis (clot retrieval with a specialized percutaneous catheter; see Chap. 7 [3].

The primary focus for the initial treatment of acute ischemic stroke is determining whether a patient who presents with acute neurological deficits is a candidate for intravenous thrombolytic therapy. Within the last two decades, the use of IV alteplase (commonly referred to as IV tPA) for acute ischemic stroke, together with the establishment of stroke systems of care, has changed the treatment "landscape" for both acute and recovery stroke care. Certified stroke centers are organizations recognized for the implementation of protocols that address the triaging and assessment of potential stroke patients quickly and that deliver selected treatments in a timely manner. At the forefront is the acute stroke team. Neurologists and non-neurologists including emergency department physicians, internists, and advanced practice clinicians comprise the modern-day providers (or LIPs – licensed independent practitioners) on the stroke team. All members of the team must understand the variable spectrum of acute stroke presentations, the critical elements of the neurological examination, the basis for imaging, the indications for treatment, and the need for specific order sets that outline subsequent inpatient care including post-lytic assessments.

6.2 Case Presentations

6.2.1 Case 1

Patient is a 48-year-old right-handed woman with a mechanical heart valve (taking warfarin) that presents with the acute onset of speech slurring, left-sided weakness, visual loss, and neglect. She arrives to the hospital within 1 h from the time of symptom onset. Her National Institute of Health Stroke Scale Score (NIHSS) is 15. Her INR is 1.1. She is taken for a STAT CT head (Fig. 6.1), which demonstrates no acute intracranial hemorrhage,

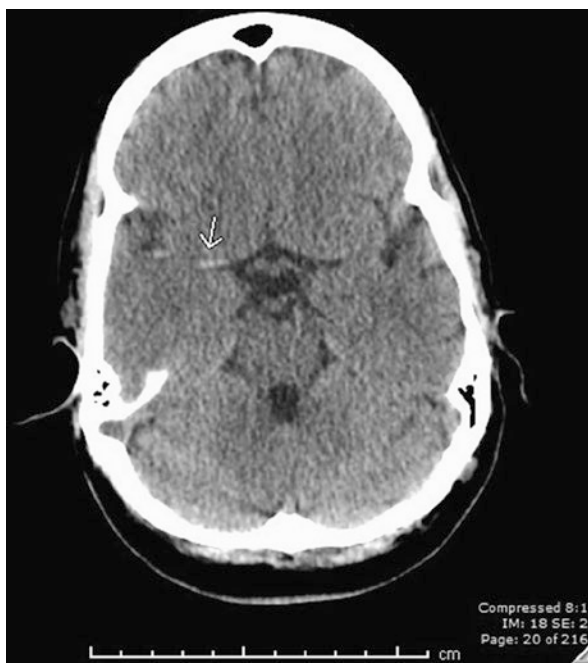

Fig. 6.1 Non-contrast head CT demonstrating a hyperdense right middle cerebral artery

but does show a hyperdense right middle cerebral artery suggestive of acute thrombus. She meets the inclusion criteria for intravenous thrombolytic therapy. IV alteplase is administered 1 h and 20 min after symptom onset. Over the next 24 h, the patient's symptoms improve with her NIHSS decreasing to 8. She is evaluated for and is accepted for acute rehabilitation. She undergoes a repeat CT scan to rule out any hemorrhage and is restarted on anticoagulation at 2 weeks after her stroke.

6.2.2 Case 2

Patient is an 87-year-old right-handed man with a history of hypertension, diabetes, and ischemic stroke (5 years ago) that presents with the onset of unsteady gait. He arrives to the hospital 4 h after the onset of his symptoms. On examination, the patient has rotary nystagmus at primary gaze, dysarthria, and right-sided dysmetria. His NIHSS is 2. The STAT head CT scan shows an area of early ischemic changes in the right cerebellum (Fig. 6.2). Despite a low NIHSS, the patient has disabling symptoms; however, his age (87 years) and comorbidities (history of diabetes and stroke) render him *not* a candidate for alteplase outside the 3 h time window. This patient is admitted to the stroke service for further diagnostic tests to understand the stroke etiology and to initiate secondary stroke prevention therapies. He is started on aspirin 81 mg daily, atorvastatin 80 mg daily and is deemed a candidate for physical and vestibular rehabilitation.

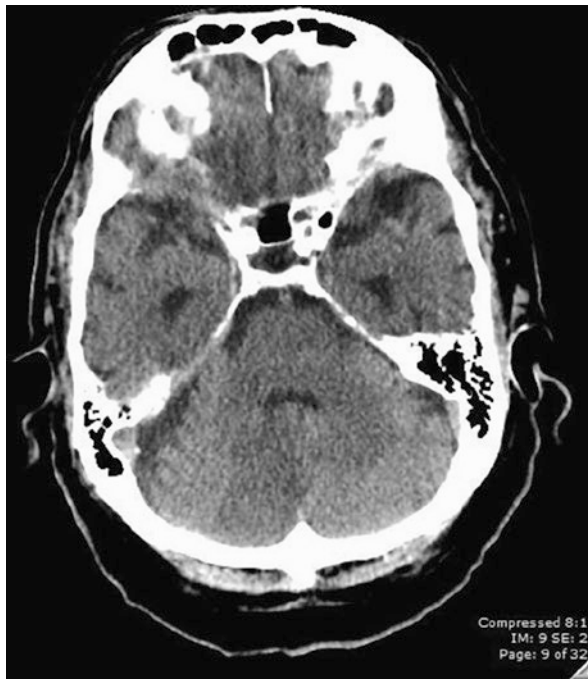

Fig. 6.2 Non-contrast head CT demonstrating a right cerebellar hypodensity

6.3 Initial Evaluation

The primary focus for the initial treatment of acute ischemic stroke is determining whether a patient who presents with acute neurological deficits is a candidate for intravenous thrombolytic therapy. This chapter focuses on a review of the pathophysiology of acute ischemic stroke, the critical thinking algorithms

that direct acute stroke care during the "golden hour" after presentation, and the role of the advanced practice clinician during the hyperacute, acute, and posttreatment recovery care process.

The two cases illustrate the diversity of acute stroke syndromes and their associated presentations, the importance of understanding neurovascular anatomy, the limitations of the currently recommended neurologic assessment (the National Institutes of Health Stroke Scale or NIHSS) in assessing posterior circulation strokes, the utility of imaging, and the criteria for IV alteplase treatment. Of the two stroke syndromes presented, the first patient has an anterior stroke syndrome and the second patient a posterior circulation syndrome. The significant contrast in the NIHSS assessments reflects the inadequacy of the NIHSS in appreciating disability caused by posterior circulation strokes.

A broad exposure to neuroanatomy and clinical correlation is important for prompt recognition of suspected acute stroke syndromes. Fortunately, many syndromes can be learned through pattern recognition (identifying specific symptoms that the patient presents with that can be correlated to and associated with loss of function in specific regions of the brain). For instance, strokes in the left hemisphere may be associated with aphasia and right-sided weakness. The patient from Case 1 had symptoms suggestive of right hemispheric dysfunction given that she had left-sided visual loss, left-sided weakness, and neglect. As shown in Case 2, posterior circulation strokes may be difficult to appreciate when depending on an NIHSS to make a diagnosis. A posterior circulation infarct must be considered if symptoms such as dysarthria, double vision, hemianopsia, and incoordination occur. Practitioners must also recognize a set of stroke syndromes that do not involve cortical signs on the examination. These strokes, called lacunar infarcts, occur in deeper brain perforating arteries commonly affecting the internal capsule,

thalamus, and pons. The associated syndromes include focal motor weakness, focal sensory disturbances clumsy-hand dysarthria, and ataxic hemiparesis.

A stroke classification scheme worth reviewing and that requires a rudimentary knowledge of neurovascular anatomy includes Bamford's Stroke Classification or the Oxfordshire Community Stroke Project [4]. Depending on the presence of cortical dysfunction and the extent of deficit, anterior strokes can be classified into a total anterior stroke or partial anterior stroke. If the patient has a cranial nerve palsy, bilateral motor deficits, conjugate eye movement problems, cerebellar dysfunction, or an isolated hemianopsia, patients can be classified as having a posterior circulation stroke. Pure sensory or motor deficits along with other small vessel syndromes described above can be categorized as a lacunar stroke.

Classification systems and scales are not a replacement for the neurological examination, which will refine localization and help the practitioner differentiate neurovascular from non-neurovascular presentations. The neurological examination will allow the stroke team to differentiate impairments stemming from the peripheral nervous system, such as hand weakness from a small cortical stroke as opposed to an ulnar neuropathy. It will also allow the advanced practice clinician to appreciate ocular findings, incoordination, and gait instability which are undervalued or not tested in the NIHSS.

Posterior circulation strokes are missed more frequently than anterior circulation strokes [5]. Vertigo evaluations can be challenging, especially when the patient has overwhelming nausea and head-motion intolerance. Additionally, focal signs on the exam may be absent in cerebellar strokes. For these cases, the neurologist and non-neurologist should be proficient in bedside testing that evaluates the vestibular-ocular reflex for

Table 6.1 Common stroke mimics

Acute vestibular neuritis
Cervical radiculopathy
Migraine
Seizure
Demyelinating disease
Hypoglycemia
Conversion disorder
Metabolic or toxic encephalopathy

corrective saccades, direction-changing nystagmus on eccentric gaze, and skew deviation. The acronym for the examination is called HINTS, which stands for head impulse testing, nystagmus, and test of skew deviation. A negative HINTS examination (which includes an abnormal head impulse finding, absence of nystagmus, and absence of a skew deviation) was found to be more sensitive than an early MRI of the brain for excluding stroke [6, 7].

It is estimated that up to 50% of acute presentations felt to be stroke are stroke mimics (Table 6.1) [8]. Most acute stroke responders will not have access to performing a brain MRI to confirm stroke, but will have to rely upon history, the neurological examination, and a head CT to determine whether to give IV alteplase [9]. Nevertheless, current practice supports have supported rapid treatment at the expense of a confirmatory diagnosis, citing that the risk of a complication from thrombolytics is very low.

6.4 Management and Interventions

For the purposes of understanding the time-sensitive nature of stroke, the assessment, stabilization, diagnosis, and management in the first few hours after symptom onset is referred to as the *hyperacute* phase of stroke care. This time window is more broadly defined as the first 24 h after contact with the healthcare

system and includes interaction with the pre-hospital personnel (EMS) and with the emergency department staff and acute stroke team (which may also include neurosurgeons, neurointerventionalists, and the critical care unit staff). The primary goal of care during this time frame is the rapid and efficient evaluation of patients presenting with neurological deficits that would benefit from early treatment therapies (to preserve the penumbra). Reference to the *acute* phase of stroke care includes the management of stroke patients during the early recovery stage and includes the time while hospitalized (several days) or the first 30 days after the index stroke, depending on the specific organization's scope of practice [10]. During the acute phase of care, diagnostic tests to understand the possible stroke etiology are ordered; secondary stroke prevention strategies are implemented; and promotion of early recovery and prevention of complications are outlined. For the individualized care plan, a patient- and family-centered education module for post discharge recovery is initiated.

In addition to the above operational phases of care, a key time frame within the stroke care trajectory is the time window from when the patient's symptoms begin (or when the patient was last known to be at his/her baseline) to the time when treatment is started. Depending on the available therapy options, patient-related variables, and clinical trial enrollment criteria, the treatment time window can vary from 3.0 h up to 12–24 h. The 3.0 h time window reflects the results of the 1995 NINDS trial which showed a significant outcome benefit for patients treated with intravenous alteplase [11]. The 4.5 h time window reflects the results of the 2008 ECASS III trial in which selected patients had a significantly improved outcome when treated with intravenous alteplase up to 4.5 h after symptom onset [12]. The stroke treatment time window that is extended out to 12–24 h reflects the additional treatment options such as mechanical thrombolysis and enrollment in acute stroke clinical trials for which specific pharmacologic or other experimental therapies might be offered.

So for the clinicians involved in the acute stroke code process, this time window defines "acute," it sets parameters for when the stroke code is activated, and it directs both the pre-hospital and stroke team efforts for early, efficient, and rapid evaluation.

6.4.1 Stroke Systems of Care

As mentioned earlier, there has been a revolutionary change in the organized capabilities of medical facilities to respond to the acute care needs of stroke patients. Over the last 15 years, hospitals have embraced the concept of disease-specific care certification for stroke as evidenced by the work of national certification entities such as The Joint Commission (TJC), Det Norske Veritas (DNV), and Healthcare Facilities Accreditation Program (HFAP). The impetus for the establishment of certified stroke centers was the 2000 publication of the consensus statement by Alberts et al. in the Journal of the American Medical Association, suggesting that elements of a stroke center would standardize and improve overall stroke care [13]. In collaboration with the American Heart Association (AHA)/American Stroke Association (ASA), The Joint Commission offers three levels of advanced stroke certification with specific requirements for meeting standards set forth by national clinical practice guidelines for stroke care. The goal is to afford every facility with the required resources to have the capability of caring for acute stroke patients across the continuum [14].

6.4.2 Acute Stroke Code

With the growing interest in organizing systems of care for stroke patients and with a shortage of vascular neurologists across the USA, opportunities for advanced practice clinicians to play a critical role in the evaluation and management of acute stroke patients have expanded across urban, suburban, and rural

acute care settings [15]. More healthcare organizations are taking an interest in achieving stroke center certification and are integrating APCs in the hyperacute phase of stroke care to meet the standards set forth by the certifying organizations to meet time targets and care metrics. In fact, for institutions seeking comprehensive stroke center certification, one or more APCs are required to take an active role in the delivery of stroke expertise in the clinical, education, and research domains [16, 17].

There are several acute stroke care delivery models that utilize stroke-trained APCs to link the pre-hospital, emergency department, diagnostic imaging, pharmacy, and other ancillary staff under the defined acute stroke code protocol. In some organizations, the APC is the designated first responder and is responsible for the initial neurological exam, gathering history, ordering imaging, and consulting with the on-call neurologist to review the case and determine treatment options. At larger facilities, the APC may be one member of a team of clinicians including neurology fellows, residents, or members of the ED staff. The evaluation and treatment decisions are a shared responsibility among the providers. With the expanded use of telestroke services, the APC at the remote site may be the key participant in the video-conferencing consult with the on-call telestroke vascular neurologist.

Many times EMS has provided notification of an acute stroke case before arriving at the hospital. Triage is performed in the field using one of several validated pre-hospital stroke assessment tools (Table 6.2). Based on prenotification, the acute stroke team will have been activated to provide a rapid and efficient evaluation of the patient's history (including time "last known well" or at baseline) and presenting neurological deficits (with an NIHSS assessment). A STAT non-contrast CT scan of the brain is the initial neuroimaging study ordered and performed to exclude cerebral hemorrhage as a cause for the patient's presenting symptoms. Based on a review of specific laboratory results and criteria for the administration of IV alteplase, in addition to making a clinical diagnosis of acute ischemic stroke, the stroke team will present the options for thrombolytic treatment with a

Table 6.2 Examples of pre-hospital neurologic screening assessments: the Cincinnati pre-hospital stroke screen and the Los Angeles pre-hospital stroke screen

Cincinnati pre-hospital stroke scale
Facial droop
Normal: both sides of face move equally
Abnormal: one side of face does not move as well as the other
Arm drift
Normal: both arms move the same or both arms do not move at all
Abnormal: one arm either does not move or drift down compared to the other
Speech
Normal: says correct words without slurring
Abnormal: says the wrong words, slurs words, or is unable to speak
Los Angeles pre-hospital stroke screen (LAPSS)
Last time patient known to be symptom free
Screening Criteria
Age > 45 y
No history of seizures or epilepsy
Symptom duration <4.5 hours
Not previously bedridden or wheelchair bound
Blood glucose 60–400 mg/dl
Exam
Facial smile/grimace: normal, droop
Grip: normal, weak grip, no grip
Arm: normal, drifts down, falls rapidly

full discussion of the risks and benefits associated with this treatment. The current time target from arrival in the emergency department to thrombolytic treatment is ≤60 min. Time elements of this process have been further divided with the following recommended time goals, as outlined in Table 6.3.

The acute stroke code actions described above represent the first tier of acute stroke care. A more detailed outline of additional imaging studies, relevant laboratory studies, and hemodynamic monitoring parameters is described in the 2013 AHA/ASA guidelines for the early management of patient with

Table 6.3 Recommendations for benchmark times during the stroke code

Emergency department team actions	Time
Arrival to provider evaluation	<10 min
Arrival to acute stroke team evaluation	<15 min
Arrival to CT scan "start"	<25 min
Arrival to CT scan interpretation	<45 min
Arrival to IV thrombolysis	<60 min
Arrival to disposition to the stroke unit	<3 h

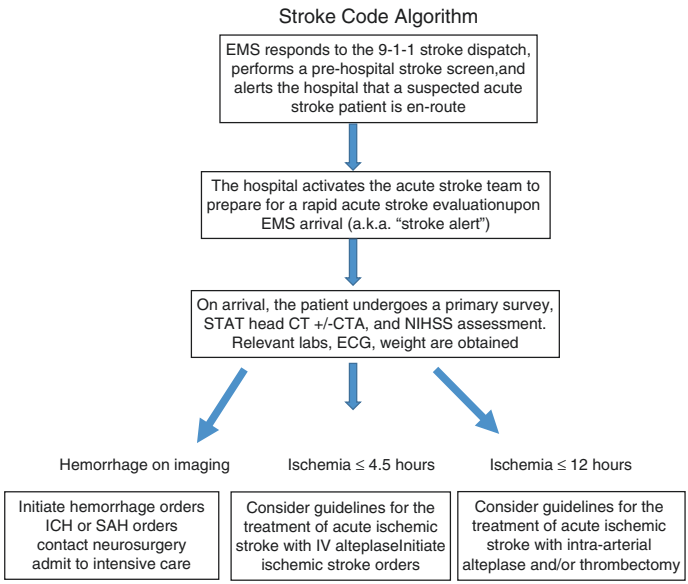

Fig. 6.3 Acute Stroke Algorithm

acute ischemic stroke. It is within the scope of practice of the APC to act as the stroke team's first responder or as a member of a larger stroke code team that may include neurology residents, emergency department staff, and/or a telestroke consultant service. Figure 6.3 outlines a typical stroke code algorithm that depicts the initial diagnostic evaluation.

6.4.3 National Institutes of Health Stroke Scale Score (NIHSS)

The NIHSS has become the standard neurologic assessment tool during the acute stroke evaluation. It is a 15-item impairment scale that evaluates the deficits from a impairment of a cerebral infarction on level of consciousness, dysarthria, language, neglect, visual loss, eye movement, sensory loss, motor strength, and coordination. This scale measures level of severity and has been shown to have concordance with infarct volume. This tool is also one of the standard assessments used in clinical trials evaluating efficacy in acute stroke therapeutics. With excellent inter-rater reliability, a major strength of the scale is that it can be learned by any member of the stroke team and it can be performed quickly. The certification is available online through the American Heart Association and the National Stroke Association and is typically mandatory for all stroke team members (Table 6.4).

The maximum recordable NIHSS score is 42 but given the laterality in most ischemic strokes, very severe strokes are scored between 25 and 31. Stroke severity has been characterized as 1–5 for mild strokes, 5–14 for moderate severity, and 15–24 for severe strokes. Outcomes and disposition are associated with NIHSS on admission. Patients with a score of 5 or less are likely to be discharged home, while patients with a scale greater than 14 more frequently require long-term skilled nursing care.

Since the NIHSS has replaced the neurological examination for many first responders to acute stroke, one must understand its weaknesses before basing treatment decisions on an isolated score. The NIHSS does not measure disability. Isolated symptoms of aphasia or a hemianopsia can yield low NIHSS that place the patient in a mild severity category but can be permanently disabling [18]. Furthermore, many institutions are using modified forms of the NIHSS which omit ataxia and dysarthria. Likewise, diplopia, dysphagia, gait instability, and nystagmus are not scored.

Table 6.4 National Institute of Health Stroke Scale (NIHSS)

1a. Level of consciousness 0 alert 1 drowsy 2 stuporous 3 coma	5a–b. Motor Arm (L/R) 6a–b. Motor Leg (L/R 0 no drift 1 drift 2 can't resist gravity 3 no effort against gravity 4 no movement
1b. LOC questions (month, age) 0 both correct 1 one correct 2 incorrect	7. Limb ataxia (finger-nose, heel-shin) 0 absent 1 present in 1 limb 2 present in 2 limbs
1c. LOC commands (close eyes, make fist) 0 both correct 1 one correct 2 incorrect	8. Sensation (pinprick) 0 normal 1 partial loss 2 severe loss
2. Best gaze 0 normal 1 partial gaze palsy 2 forced deviation	9. Best language 0 no aphasia 1 mild-mod aphasia 2 severe aphasia 3 mute
3. Visual fields 0 no visual loss 1 partial hemianopsia 2 complete hemianopsia 3 bilateral hemianopsia	10. Dysarthria 0 none 1 mild-mod 2 unintelligible
4. Facial palsy 0 normal 1 minor 2 partial 3 complete	11. Extinction and inattention 0 no neglect 1 partial neglect 2 complete neglect

A major weakness is that it undervalues posterior circulation symptoms, so acute stroke providers must maintain a high level of suspicion for stroke when these symptoms are present.

Another weakness is that the exam is highly dependent upon language. If two patients were to have identical NIHSS scores but were to have infarcts in opposite hemispheres, the patient with the right hemisphere infarct would have a larger median infarct volume [19].

Despite its weaknesses, the NIHSS stands as a common assessment tool that can be used to determine stroke severity, disposition, and outcome. The NIHSS also serves as a universal communication tool after the initial stroke assessment to detect worsening after IV tPA administration. Additionally, given the recent data supporting the use of mechanical thrombectomy in selected acute stroke patients, a new focus of stroke care has emphasized detection of large vessel occlusions. Within the first 3 h, the best cutoff NIHSS score with positive predictive value to show a large vessel occlusion is 9 or greater.

6.4.4 Neuroimaging

The gold standard imaging study for assessment of the acute ischemic stroke patient is the non-contrast head computed tomography (CT). Despite the advances made in neuroimaging, this study remains the primary modality given its accessibility and rapid interpretation. The initial objective of the study is to exclude cerebral hemorrhage which is an absolute contraindication for thrombolysis. Once hemorrhage is excluded, the next goal includes excluding a stroke mimic such as a mass lesion. Finally, it may be used to identify early ischemic changes guiding whether patients may benefit from thrombolysis and/or further catheter-based interventions.

Significant ischemic changes involving greater than one third MCA territory have generally been used as an exclusion criterion for IV thrombolysis because of its association with an

increased risk of hemorrhage after lytic therapy. The Alberta Stroke Program Early CT Score (ASPECTS) is a 10-point topographic CT scan evaluating affected brain tissue within standardized regions of the MCA territory (see link in *Helpful Links and Resources* for more information). A normal CT ASPECTS is 10, and a score of less than 7 is felt to approximate that greater than one third of the MCA is affected [20].

Many centers have access to multimodal CT and MRI; however, these studies should not delay the decision and administration of IV tPA if indicated. The American Heart Association guidelines for acute ischemic stroke recommend noninvasive intracranial vascular studies when endovascular studies are considered. Regardless, institutions vary on the patient population receiving selected imaging studies and are dependent on neuroimaging resources, radiological staff to interpret the studies, and treatment options at the local hospital.

Although not studied to affect outcomes, one can make the case that it is important to know the status of the extracranial and intracranial circulation on any acute stroke patient. This data may help provide mechanism such as diagnosing a vertebral artery dissection or carotid stenosis. In turn, the practitioner can facilitate prompt treatment paradigms to reduce the risk of recurrent stroke or worsening.

6.4.5 IV tPA

Intravenous alteplase (tPA) remains the only FDA-approved drug for the treatment of acute ischemic stroke, and its time dependence is the basis for creating a well-organized approach to diagnose stroke swiftly. During a stroke event, it is estimated that 2 million neurons die for each minute that the brain is not perfused [21]. The goal in thrombolytic therapy is to revascularize brain tissue, and IV tPA is the only FDA-approved drug for stroke that has shown to benefit acute stroke patient when administered up to 4.5 h after the onset of symptoms.

The NINDS tPA Stroke Trial part 2 evaluated the administration of IV tPA in acute ischemic stroke within 3 h. In 1995, the trial published that acute ischemic stroke patients who received IV tPA had 30% relative risk reduction (absolute risk reduction 11–15%) compared to placebo-treated patients in having minimal or no disability at 90 days. The primary outcome measures included the NIHSS, the modified Rankin Scale (mRS), the Barthel Index (BI), and the Glasgow Outcome Scale (GOS). To put this into perspective, the number of patients needed to receive treatment (NNT) to show a benefit of demonstrating minimal or no disability is 8.

Time to treatment has been demonstrated as being a critical variable that determines the benefit of thrombolysis. The most significant benefit is derived in the stroke population that is treated within 90 min. The NNT for any benefit in this population is 1.5. In 2008, the time window for demonstrated benefit from IV tPA was extended to 4.5 h in the European Cooperative Acute Stroke Study (ECASS) III. The study evaluated the efficacy of IV tPA between the 3 and 4.5 window in a restricted population. This population excluded patients over 80 years old, patients with a NIHSS >25, patients taking anticoagulation irrespective of the coagulation level, and patient with a previous history of diabetes and stroke. Results from this study revealed that the number of patients needed to treat with IV tPA within the 3–4.5 h window to demonstrate minimal or no disability is 15. Despite this data, the FDA has not extended the labeling to incorporate this change. However, the use of IV tPA within this window is endorsed by the AHA in the selected patient population.

The risk of intracerebral hemorrhage (ICH) after the administration of IV tPA provides the most angst for practitioners in the assessment of the acute ischemic stroke patient. There has been variance in the rate of symptomatic ICH (sICH) among trials, largely from varying radiographic and clinical definitions. The NINDS trial showed a sICH rate of 6.4%, and the ECASS

III trial demonstrated a rate of 2.4%. Predictors of intracerebral hemorrhage from the NINDS tPA study include patients with severe strokes and significant edema or mass effect on the baseline head CT. Thus many patients who do have symptomatic hemorrhages did not have their clinical course altered given the severity of the initial ischemic stroke. Nevertheless, overall benefit for the administration of IV tPA has still been shown in this population.

Other less common side effects of IV tPA include orolingual angioedema, systemic hemorrhage, and reportedly myocardial rupture. Orolingual angioedema reaction is typically mild, may be transient and often contralateral to the hemisphere affected by the stroke. Systemic hemorrhage can occur anywhere in the brain and occurred in 1.6% of IV tPA-treated patients in the NINDS trial. However, patients at elevated risk were excluded from the trial and included patients with evidence of active bleeding, patients with a gastric or urinary tract hemorrhage within 21 days, major surgery within 14 days, and an arterial puncture at a noncompressible site in 7 days.

Given the risk for bleeding and other potential complications, the current (2013) AHA guidelines for alteplase administration for acute ischemic stroke include inclusion/exclusion statements that assist clinicians with the decision-making process for treatment during the stroke code event (Table 6.5). The 1995 NINDS trial methods appropriately outlined conservative IV alteplase eligibility criteria, but since then, there have been several studies demonstrating broader considerations for thrombolysis and there have been revisions to the pharmaceutical company drug insert and a subsequent scientific statement proposing expanding eligibility criteria to afford more patients both treatment and potentially better outcomes. Demarschalk and his colleagues compared the current 2013 AHA guidelines with alteplase prescribing information and acknowledge that clinician experience and patient-specific factors together with the guidelines currently direct treatment recommendations. However, advanced

Table 6.5 Criteria for tPA administration

Inclusion criteria
Diagnosis of ischemic stroke causing measurable neurological deficit
Onset of symptoms <3 hours before treatment begins
Age > 18 years
Exclusion criteria
Significant head trauma or stroke in the previous 3 months
Symptoms suggestive of SAH
Arterial puncture at noncompressible site in previous 7 days
History of previous intracranial hemorrhage
Intracranial neoplasm, AVM, or aneurysm
Recent intracranial or intraspinal surgery
Elevated blood pressure (SBP >185 or DBP >110
Active internal bleeding
Acute bleeding diathesis, including but not limited to Plt count <100,000/mm^3, heparin received within 48 hours, or aPTT above normal, use of anticoagulant with INR >1.7 or PT >15 s, and use of direct thrombin inhibitors or direct factor Xa inhibitors with elevated laboratory tests
Blood glucose <50 mg/dL
CT demonstrates multilobar infarction
Relative exclusion criteria
Minor rapidly improving stroke symptoms (clearing spontaneously)
Pregnancy
Seizure at onset with postictal residual neurological impairments
Major surgery or serious trauma within 14 days
Recent GI or urinary tract hemorrhage (within previous 21 days)
Recent acute myocardial infarction (within previous 3 months)

practice clinicians should be familiar with their respective institution's protocols for thrombolytic therapies and the currently published guidelines.

Dosing of IV alteplase is weight-based and is prepared based on a 0.9 mg/kg (up to a maximum of 90 mg) formulation. It is administered in divided doses with 10% of the calculated

dose administered as a bolus over 1 min, and the remainder (90%) administered over the subsequent 1 h. Additional fluids are infused through the tubing to deliver the remaining drug. It is a focus of bedside nursing care to monitor for potential complications following alteplase administration. The stroke team directs the frequency of vital signs and neurologic assessments during the first 24 h after thrombolytic administration.

6.4.6 Post Thrombolytic Care

Most protocols direct patients to an intensive care unit for frequent neurologic and cardiovascular monitoring after IV alteplase treatment. Specific parameters are recommended for monitoring blood pressure, heart rate, oxygenation, and the neurological exam. Nurses specializing in acute stroke care follow post thrombolytic surveillance assessments to monitor for potential complications and neurologic deterioration for the first 24 h after treatment. Complications post stroke and post thrombolytics include bleeding, cerebral edema, aspiration, hypertension, cardiac arrhythmias, seizures, and subsequent neurologic deterioration. For a detailed understanding of the post thrombolytic intensive medical and nursing care, the AHA/ASA clinical practice guideline is a useful reference to guide clinical care during the first 24–48 h after admission. Stroke centers support evidence-based, multidisciplinary order sets or clinical pathways (specific to the care of an acute ischemic stroke patient) that outline the management during the acute phase of recovery care. The advanced practice clinician is ideally suited to direct the medical care based on a thorough understanding of the patient's stroke syndrome presentation, the affected cerebrovascular territory, possible stroke etiology, and recommended secondary prevention options.

Summary Points

- Organizations committed to the care of patients presenting with acute stroke syndromes support evidence-based protocols and necessary resources to deliver efficient and time-sensitive thrombolytic therapy.
- Stroke syndromes are variable; patients may present with a constellation of symptoms that require a knowledge of neurovascular anatomy and potential stroke mimics.
- Rapid interpretation of the non-contrast CT of the brain excludes hemorrhage; the diagnosis of acute ischemic stroke is clinical diagnosis that determines treatment eligibility.
- The NIHSS is the "gold standard" initial stroke assessment for quantifying neurological deficit(s) and is used to track the efficacy of thrombolytic treatment.
- Intravenous alteplase remains the only drug approved for the treatment of acute ischemic stroke.

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