Part 11: Adult Stroke

2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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Nearly 15 years of increased stroke education and organization has produced significant strides in public awareness and development of stroke systems of care. Despite these successes, though, each year 795 000 people suffer a new or repeat stroke, and stroke remains the third leading cause of death in the United States.[1] Many advances have been made in stroke prevention, treatment, and rehabilitation, but arguably the greatest gains have been in the area of stroke systems of care. Integrating public education, 911 dispatch, prehospital detection and triage, hospital stroke system development, and stroke unit management have led to significant improvements in stroke care. Not only have the rates of appropriate fibrinolytic therapy increased over the past 5 years, but also overall stroke care has improved, in part through the creation of stroke centers.[2] To achieve further improvement in reducing the burden of stroke, healthcare providers, hospitals, and communities must continue to develop systems to increase the efficiency and effectiveness of stroke care.[3] The "D's of Stroke Care" remain the major steps in diagnosis and treatment of stroke and identify the key points at which delays can occur.[4,5]

- Detection: Rapid recognition of stroke symptoms
- Dispatch: Early activation and dispatch of emergency medical services (EMS) system by calling 911
- Delivery: Rapid EMS identification, management, and transport
- Door: Appropriate triage to stroke center
- Data: Rapid triage, evaluation, and management within the emergency department (ED)
- Decision: Stroke expertise and therapy selection
- Drug: Fibrinolytic therapy, intra-arterial strategies
- Disposition: Rapid admission to stroke unit, critical-care unit

This chapter summarizes the early management of acute ischemic stroke in adult patients. It describes care from out-of-hospital therapy through the first hours of in-hospital therapy. For additional information about the management of acute ischemic stroke, see the American Heart Association (AHA)/American Stroke Association (ASA) guidelines for the management of acute ischemic stroke.[3,6,7]

Management Goals

The overall goal of stroke care is to minimize acute brain injury and maximize patient recovery. The time-sensitive nature of stroke care is central to the establishment of successful stroke systems, hence the commonly used refrain "Time is Brain." The AHA and ASA have developed a community-oriented "Stroke Chain of Survival" that links specific actions to be taken by patients and family members with recommended actions by out-of-hospital healthcare responders, ED personnel, and in-hospital specialty services. These links, which are similar to those in the Adult Chain of Survival for victims of sudden cardiac arrest, include rapid recognition of stroke warning signs and activation of the emergency response system (call 911); rapid EMS dispatch, transport, and prehospital notification; triage to a stroke center; and rapid diagnosis, treatment, and disposition in the hospital.

The AHA ECC stroke guidelines focus on the initial out-of-hospital and ED assessment and management of the patient with acute stroke as depicted in the algorithm Goals for Management of Patients With Suspected Stroke (Figure). The time goals of the National Institute of Neurological Disorders and Stroke (NINDS)[8] are illustrated on the left side of the algorithm as clocks. A sweep hand depicts the goal in minutes from ED arrival to task completion to remind the clinician of the time-sensitive nature of management of acute ischemic stroke.

The sections below summarize the principles and goals of stroke system development and emergency assessment and management, as well as highlight new recommendations and training issues. The text refers to the numbered boxes in the algorithm.

Stroke Systems of Care

The regionalization of stroke care was not widely considered in the era before availability of effective acute therapies. With the NINDS recombinant tissue plasminogen activator (rtPA) trial, the crucial need for local partnerships between academic medical centers and community hospitals became a reality.[9]

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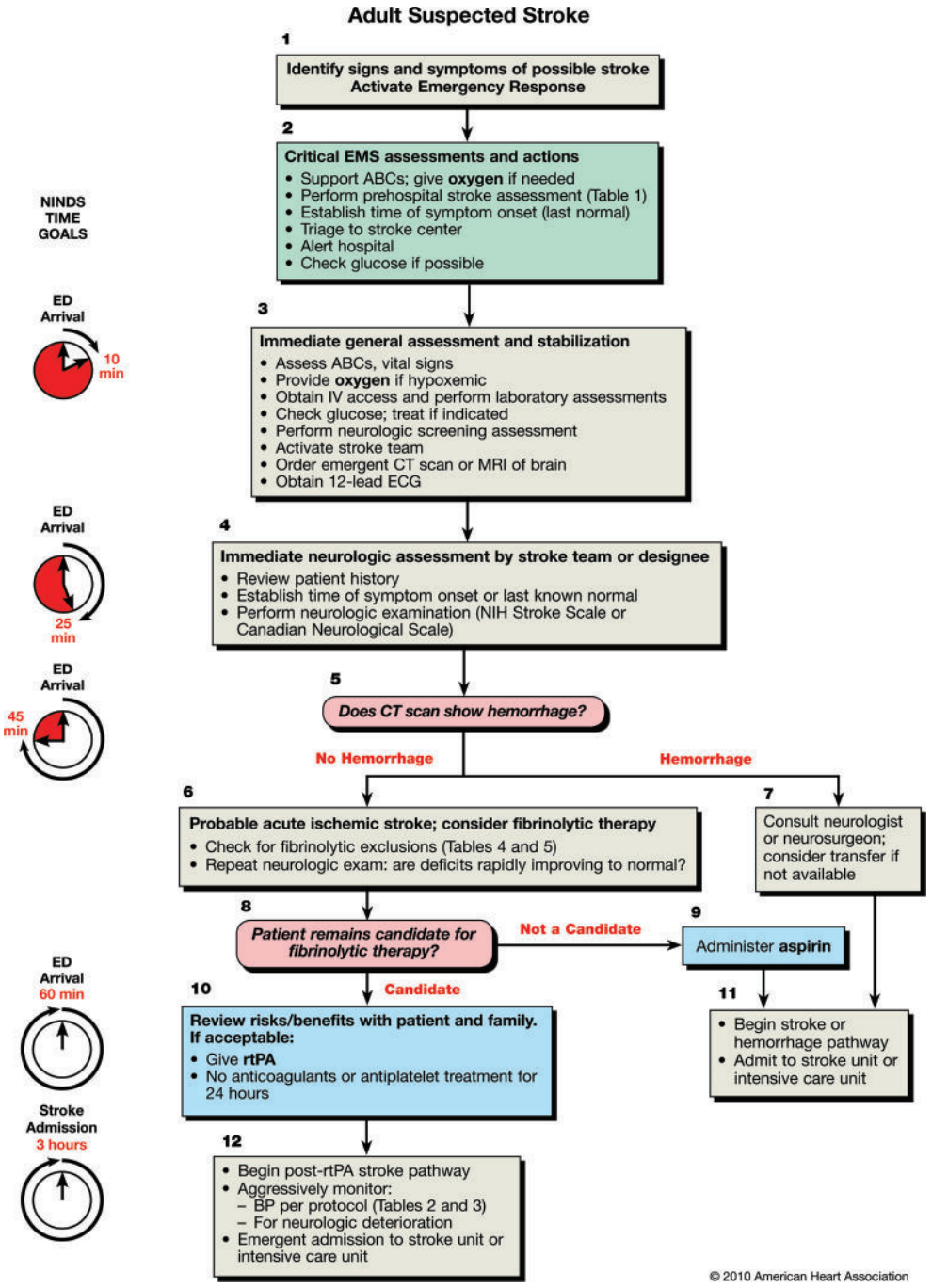

Figure. Goals for management of patients with suspected stroke.

The time-sensitive nature of stroke requires such an approach, even in densely populated metropolitan centers. The idea of a "stroke-prepared" hospital emerged after the United States Food and Drug Administration (FDA) approved rtPA for stroke. In 2000 the Brain Attack Coalition provided a description of "primary stroke centers," which would ensure that best practices for stroke care (acute and beyond) would be offered in an organized fashion.[7] The logic of having a multitiered system such as that provided for trauma was evident. Therefore, in 2005 the Brain Attack Coalition followed the statement on primary stroke centers with recommendations for comprehensive stroke centers.[6] Following the establishment of primary stroke centers and comprehensive stroke centers, the new concept of a stroke-prepared hospital has recently emerged. This stroke-prepared hospital can access stroke expertise via telemedicine. The comparison with a trauma system with Level 1, 2, and 3 centers is rational and quite intuitive to emergency care providers familiar with such configurations.

Substantial progress has been made toward regionalization of stroke care. Several states have passed legislation requiring prehospital providers to triage patients with suspected stroke to designated stroke centers. This is contingent on the accuracy of dispatch, an area where further improvement is

needed.[10] The integration of EMS into regional stroke models is crucial for improvement of patient outcomes.[11] Efforts have been strong in many regions, especially in regions with relatively high population density and large critical mass of stroke centers to effectively create a model for stroke regionalization.[12] Although a large proportion of the US population is now within close proximity to a stroke center, it is not clear how many stroke patients arrive at stroke-prepared hospitals.

Additional work is needed to expand the reach of regional stroke networks. Healthcare professionals working in EMS, emergency medicine, or emergency nursing can also assist in this process by determining which hospitals in their community offer care concordant with the Brain Attack Coalition recommendations for primary stroke centers.[7,11,13,14]

Stroke Recognition and EMS Care (Box 1)

Stroke Warning Signs

Identifying clinical signs of possible stroke is important because recanalization strategies (intravenous [IV] fibrinolysis and intra-arterial/catheter-based approaches) must be provided within the first few hours from onset of symptoms.[9,15,16] Most strokes occur at home, and just over half of all victims of acute stroke use EMS for transport to the hospital.[17–21] Stroke knowledge among the lay public remains poor.[22,23] These factors can delay EMS access and treatment, resulting in increased morbidity and mortality. Community and professional education is essential[22,24] and has successfully increased the proportion of stroke patients treated with fibrinolytic therapy.[25–27]

Patient education efforts are most effective when the message is clear and succinct. The signs and symptoms of stroke include sudden weakness or numbness of the face, arm, or leg, especially on one side of the body; sudden confusion; trouble speaking or understanding; sudden trouble seeing in one or both eyes; sudden trouble walking, dizziness, loss of balance or coordination; or sudden severe headache with no known cause. Educational efforts need to couple the knowledge of the signs and symptoms of stroke with action—call 911.

911 and EMS Dispatch

EMS systems of care include both 911 emergency medical dispatch centers and EMS response personnel. It is imperative that the stroke system of care provide education and training to 911 and EMS personnel to minimize delays in prehospital dispatch, assessment, and transport. Emergency medical telecommunicators must identify and provide high-priority dispatch to patients with stroke symptoms. Current literature suggests that 911 telecommunicators do not recognize stroke well and that the use of scripted stroke-specific screens during a 911 call may be helpful.[10,28] Studies are ongoing to investigate the effectiveness of such a stroke assessment tool for 911 telecommunicators.[29,30]

In settings where ground transport to a stroke center is potentially long, air medical services may be used. Regional stroke resources work with EMS agencies to establish criteria for the use of air medical transport for patients with acute stroke and determine the most appropriate destination based on distance and the hospital's stroke capability. As with ground transportation, prehospital notification should be performed to ensure appropriate activation of stroke resources.

Table 1. The Cincinnati Prehospital Stroke Scale

Facial droop (have patient show teeth or smile)

- Normal—both sides of face move equally
- Abnormal—one side of face does not move as well as the other side

Arm drift (patient closes eyes and holds both arms straight out for 10 seconds)

- Normal—both arms move the same or both arms do not move at all (other findings, such as pronator drift, may be helpful)
- Abnormal—one arm does not move or one arm drifts down compared with the other

Abnormal speech (have the patient say "you can't teach an old dog new tricks")

- Normal—patient uses correct words with no slurring
- Abnormal—patient slurs words, uses the wrong words, or is unable to speak

Interpretation: If any 1 of these 3 signs is abnormal, the probability of a stroke is 72%.

Stroke Assessment Tools

EMS providers can identify stroke patients with reasonable sensitivity and specificity, using abbreviated out-of-hospital tools such as the Cincinnati Prehospital Stroke Scale (CPSS)[31–34] (Table 1) or the Los Angeles Prehospital Stroke Screen (LAPSS).[35,36] The CPSS is based on physical examination only. The EMS provider checks for 3 physical findings: facial droop, arm weakness, and speech abnormalities. The presence of a single abnormality on the CPSS has a sensitivity of 59% and a specificity of 89% when scored by prehospital providers.[33] Another assessment tool, the LAPSS, requires that the provider rule out other causes of altered level of consciousness (eg, history of seizures, hypoglycemia) and then identify asymmetry in any of 3 examination categories: facial smile or grimace, grip, and arm strength. The LAPSS has a sensitivity of 93% and a specificity of 97%.[35,36]

With standard training in stroke recognition, paramedics demonstrated a sensitivity of 61% to 66% for identifying patients with stroke.[34,37,38] After receiving training in use of a stroke assessment tool, paramedic sensitivity for identifying patients with stroke increased to 86% to 97%.[36,39,40] We recommend that all paramedics and emergency medical technicians-basic (EMT-basic) be trained in recognition of stroke using a validated, abbreviated out-of-hospital screening tool such as the CPSS or LAPSS (Class I, LOE B).

Prehospital Management and Triage (Box 2)

As with any other time-sensitive acute illness, prehospital providers must perform an initial assessment and intervene if necessary to provide cardiopulmonary support. In addition, for stroke, providers must clearly establish the *time of onset of symptoms*. This time represents time zero for the patient. If the patient wakes from sleep or is found with symptoms of a stroke, the time of onset of symptoms is defined as the last time the patient was observed to be normal. EMS providers must be able to support cardiopulmonary function, perform rapid stroke assessment, establish time of onset of symptoms

(or the last time the patient was known to be normal), triage and transport the patient, and provide prearrival notification to the most appropriate receiving hospital.[31,41–44]

Patients with acute stroke are at risk for respiratory compromise from aspiration, upper airway obstruction, hypoventilation, and (rarely) neurogenic pulmonary edema. The combination of poor perfusion and hypoxemia will exacerbate and extend ischemic brain injury and has been associated with worse outcome from stroke.[45] Both out-of-hospital and in-hospital medical personnel should administer supplemental oxygen to hypoxemic (ie, oxygen saturation <94%) stroke patients (Class I, LOE C) or those with unknown oxygen saturation.

Although blood pressure management is a component of the ED care of stroke patients, there are no data to support initiation of hypertension intervention in the prehospital environment. Unless the patient is hypotensive (systolic blood pressure <90 mm Hg), prehospital intervention for blood pressure is not recommended (Class III, LOE C).

Transport and Destination Hospital

EMS providers should consider transporting a witness, family member, or caregiver with the patient to verify the time of stroke symptom onset. En route to the facility, providers should continue to support cardiopulmonary function, monitor neurologic status, check blood glucose if possible, and provide prehospital notification.

Prearrival hospital notification by the transporting EMS unit has been found to significantly increase the percentage of patients with acute stroke who receive fibrinolytic therapy.[46–48] Bypass of community hospitals in favor of transporting patients directly to a stroke center has undergone investigations that merit attention. Investigators in New York, Canada, Italy, and Australia have performed before-and-after studies examining the difference in rates of rtPA administration after implementation of a hospital bypass protocol for EMS. All have found significantly larger percentages of patients with ischemic stroke treated with rtPA when patients are transported directly to stroke centers.[47,49,50] Recently investigators have begun to examine the impact of direct activation of stroke teams by EMS.[50,51]

EMS providers must rapidly deliver the patient to a medical facility capable of providing acute stroke care and provide prearrival notification to the receiving facility.[41,46,48] Each receiving hospital should define its capability for treating patients with acute stroke using the definitions established for stroke-prepared hospitals, primary stroke centers, and comprehensive stroke centers[3,6,7] and should communicate this information to the EMS system and the community. Although not every hospital is capable of organizing the necessary resources to safely administer fibrinolytic therapy, every hospital with an ED should have a written plan that is communicated to EMS systems describing how patients with acute stroke are to be managed in that institution. The plan should detail the roles of healthcare professionals in the care of patients with acute stroke and define which patients will be treated with fibrinolytic therapy at that facility and when transfer to another hospital with a dedicated stroke unit is appropriate.

The role of stroke centers and in particular stroke units continues to be defined, but a growing body of evidence[47,49,50,52–58] indicates a favorable benefit from triage of stroke patients directly to designated stroke centers (Class I, LOE B). EMS systems should establish a stroke destination preplan to enable EMS providers to direct patients with acute stroke to appropriate facilities. When multiple stroke hospitals are within similar transport distances, EMS personnel should consider triage to the stroke center with the highest capability of stroke care.

Multiple randomized clinical trials and meta-analyses in adults[50,59–62] document consistent improvement in 1-year survival rate, functional outcome, and quality of life when patients hospitalized with acute stroke are cared for in a dedicated stroke unit by a multidisciplinary team experienced in managing stroke. Although the studies reported were conducted outside the United States at in-hospital units that provided both acute care and rehabilitation, the improved outcomes were apparent very early in stroke care. These results should be relevant to the outcome of dedicated stroke units staffed with experienced multidisciplinary teams in the United States. When such a facility is available within a reasonable transport interval, stroke patients who require hospitalization should be admitted there (Class I, LOE B).

In-Hospital Care

Initial ED Assessment and Stabilization (Box 3)

Protocols should be used in the ED to minimize delay to definitive diagnosis and therapy: "Time is Brain."[43] As a goal, ED personnel should assess the patient with suspected stroke within 10 minutes of arrival in the ED. General care includes assessment, cardiopulmonary support (airway, breathing, circulation), and evaluation of baseline vital signs. Administration of oxygen to hypoxemic patients with stroke (oxygen saturation <94%) is recommended (Class I, LOE C).

On arrival ED personnel should establish or confirm IV access and obtain blood samples for baseline studies (eg, complete blood count, coagulation studies, blood glucose). If not already identified in the prehospital setting, ED staff should promptly identify and treat hypoglycemia. The ED physician should perform a neurologic screening assessment, order an emergent computed tomography (CT) scan of the brain, and activate the stroke team or arrange for consultation with a stroke expert.

A 12-lead electrocardiogram (ECG) does not take priority over the CT scan but may identify a recent acute myocardial infarction or arrhythmias (eg, atrial fibrillation) as the cause of an embolic stroke. If the patient is hemodynamically stable, treatment of other arrhythmias, including bradycardia, premature atrial or ventricular contractions, or asymptomatic atrioventricular conduction block, may not be necessary.[63] There is general agreement to recommend cardiac monitoring during the first 24 hours of evaluation in patients with acute ischemic stroke to detect atrial fibrillation and potentially life-threatening arrhythmias.[64]

Assessment (Box 4)

The treating physician should review the patient's history and verify time of onset of symptoms.[65–67] This may require interviewing out-of-hospital providers, witnesses, and family members to establish the time that the patient was last known to be normal. Neurologic assessment is performed, incorpo-

Table 2. Potential Approaches to Arterial Hypertension in Acute Ischemic Stroke Patients Who Are Potential Candidates for Acute Reperfusion Therapy

Patient otherwise eligible for acute reperfusion therapy except that blood pressure is >185/110 mm Hg

- Labetalol 10–20 mg IV over 1–2 minutes, may repeat ×1, or
- Nicardipine IV 5 mg/hr, titrate up by 2.5 mg/hr every 5–15 minutes, maximum 15 mg/hr; when desired blood pressure reached, lower to 3 mg/hr, or
- Other agents (hydralazine, enalaprilat, etc) may be considered when appropriate

If blood pressure is not maintained at or below 185/110 mm Hg, do not administer rtPA

Management of blood pressure during and after rtPA or other acute reperfusion therapy:

- Monitor blood pressure every 15 minutes for 2 hours from the start of rtPA therapy; then every 30 minutes for 6 hours; and then every hour for 16 hours

If systolic BP 180–230 mm Hg or diastolic BP 105–120 mm Hg

- Labetalol 10 mg IV followed by continuous IV infusion 2–8 mg/min, or
- Nicardipine IV 5 mg/h, titrate up to desired effect by 2.5 mg/hr every 5–15 minutes, maximum 15 mg/h

If blood pressure not controlled or diastolic BP >140 mm Hg, consider sodium nitroprusside

rating either the National Institutes of Health Stroke Scale (NIHSS) or the Canadian Neurological Scale (CNS) (see the ASA website: *www.strokeassociation.org*).

Management of hypertension in the stroke patient is dependent on fibrinolytic eligibility. For patients potentially eligible for fibrinolytic therapy, blood pressure must be ≤185 mm Hg systolic and ≤110 mm Hg diastolic to limit the risk of bleeding complications. Because the maximum interval from onset of stroke until effective treatment of stroke with rtPA is limited, most patients with sustained hypertension above these levels (ie, systolic blood pressure >185 mm Hg or diastolic blood pressure >110 mm Hg) will not be eligible for IV rtPA (Tables 2 and 3).[68]

Imaging (Box 5)

Ideally the CT scan should be completed within 25 minutes of the patient's arrival in the ED and should be interpreted within 45 minutes of ED arrival. Centers may perform more advanced neurologic imaging (multimodal magnetic resonance imaging [MRI], CT perfusion, and CT angiography), but obtaining these studies should not delay initiation of IV rtPA in eligible patients. Emergent CT or MRI scans of patients with suspected stroke should be promptly evaluated by a physician with expertise in interpretation of these studies.[69] During the first few hours of an ischemic stroke the noncontrast CT scan may not indicate signs of brain ischemia. If the CT scan shows no evidence of intracerebral hemorrhage, the patient may be a candidate for fibrinolytic therapy (Boxes 6 and 8). If hemorrhage is noted on the CT scan, the patient is not a candidate for fibrinolytic therapy. Consult a neurologist or neurosurgeon and consider transfer as needed for appropriate care (Box 7).

Table 3. Approach to Arterial Hypertension in Acute Ischemic Stroke Patients Who Are *Not* Potential Candidates for Acute Reperfusion Therapy

Consider lowering blood pressure in patients with acute ischemic stroke if systolic blood pressure >220 mm Hg or diastolic blood pressure >120 mm Hg

Consider blood pressure reduction as indicated for other concomitant organ system injury

- Acute myocardial infarction
- Congestive heart failure
- Acute aortic dissection

A reasonable target is to lower blood pressure by 15% to 25% within the first day

If hemorrhage is not present on the initial CT scan and the patient is not a candidate for fibrinolytic therapy for other reasons, consider administration of aspirin (Box 9) either rectally or orally after the patient is screened for dysphagia (see below). Admit the patient to a stroke unit (if available) for careful monitoring (Box 11).

Fibrinolytic Therapy (Boxes 6, 8, and 10)

The treating physician should review the inclusion and exclusion criteria for IV fibrinolytic therapy (Tables 4 and 5) and perform a repeat neurologic examination incorporating the NIHSS or CNS. If the patient's neurologic signs are spontaneously clearing (ie, function is rapidly improving to normal and is near baseline), administration of fibrinolytics may not be required (Box 6).[64]

As with all medications, fibrinolytics have potential adverse effects. The physician must verify that there are no exclusion criteria, consider the risks and benefits to the patient, and be prepared to monitor and treat any potential complications. The major complication of IV rtPA for stroke is symptomatic intracranial hemorrhage. This complication occurred in 6.4% of the 312 patients treated in the NINDS trials[9] and 4.6% of the 1135 patients treated in 60 Canadian centers.[70] A meta-analysis of 15 published case series on the open-label use of rtPA for acute ischemic stroke in general clinical practice showed a symptomatic hemorrhage rate of 5.2% of 2639 patients treated.[71] Other complications include orolingual angioedema (occurs in approximately 1.5% of patients), acute hypotension, and systemic bleeding. In one large prospective registry, major systemic bleeding was uncommon (0.4%) and usually occurred at the site of femoral puncture for acute angiography.[70,72]

If the patient remains a candidate for fibrinolytic therapy (Box 8), the physician should discuss the risks and potential benefits of the therapy with the patient or family if available (Box 10). After this discussion, if the patient/family elects to proceed with fibrinolytic therapy, begin the rtPA bolus and infusion as quickly as possible and begin the stroke pathway of care (see below). Careful dose calculation and removal of excess rtPA help prevent inadvertent administration of excess rtPA. Typically neither anticoagulant nor antiplatelet treatment may be administered for 24 hours after administration of rtPA until a repeat CT scan at 24 hours shows no hemorrhagic transformation.

Several studies[9,15,70] have documented a higher likelihood of good to excellent functional outcome when rtPA is

Table 4. Inclusion and Exclusion Characteristics of Patients With Ischemic Stroke Who Could Be Treated With rtPA Within 3 Hours From Symptom Onset

Inclusion criteria

- Diagnosis of ischemic stroke causing measurable neurologic deficit
- Onset of symptoms <3 hours before beginning treatment
- Age ≥18 years

Exclusion criteria

- Head trauma or prior stroke in previous 3 months
- Symptoms suggest subarachnoid hemorrhage
- Arterial puncture at noncompressible site in previous 7 days
- History of previous intracranial hemorrhage
- Elevated blood pressure (systolic >185 mm Hg or diastolic >110 mm Hg)
- Evidence of active bleeding on examination
- Acute bleeding diathesis, including but not limited to
  - –Platelet count <100 000/mm^3
  - –Heparin received within 48 hours, resulting in aPTT >upper limit of normal
  - –Current use of anticoagulant with INR >1.7 or PT >15 seconds
- Blood glucose concentration <50 mg/dL (2.7 mmol/L)
- CT demonstrates multilobar infarction (hypodensity >1/3 cerebral hemisphere)

Relative exclusion criteria

Recent experience suggests that under some circumstances—with careful consideration and weighing of risk to benefit—patients may receive fibrinolytic therapy despite 1 or more relative contraindications. Consider risk to benefit of rtPA administration carefully if any of these relative contraindications is present

- Only minor or rapidly improving stroke symptoms (clearing spontaneously)
- Seizure at onset with postictal residual neurologic impairments
- Major surgery or serious trauma within previous 14 days
- Recent gastrointestinal or urinary tract hemorrhage (within previous 21 days)
- Recent acute myocardial infarction (within previous 3 months)

rtPA indicates recombinant tissue plasminogen activator; aPTT, activated partial thromboplastin time; INR, international normalized ratio; and PT, prothrombin time.

Table 5. Additional Inclusion and Exclusion Characteristics of Patients With Ischemic Stroke Who Could Be Treated With rtPA From 3 to 4.5 Hours From Symptom Onset

Inclusion criteria

- Diagnosis of ischemic stroke causing measurable neurologic deficit
- Onset of symptoms 3 to 4.5 hours before beginning treatment

Exclusion criteria

- Age >80 years
- Severe stroke (NIHSS >25)
- Taking an oral anticoagulant regardless of INR
- History of both diabetes and prior ischemic stroke

Notes

- The checklist includes some FDA-approved indications and contraindications for administration of rtPA for acute ischemic stroke. Recent guideline revisions have modified the original FDA criteria. A physician with expertise in acute stroke care may modify this list
- Onset time is either witnessed or last known normal
- In patients without recent use of oral anticoagulants or heparin, treatment with rtPA can be initiated before availability of coagulation study results but should be discontinued if INR is >1.7 or PT is elevated by local laboratory standards
- In patients without history of thrombocytopenia, treatment with rtPA can be initiated before availability of platelet count but should be discontinued if platelet count is <100 000/mm^3

rtPA indicates recombinant tissue plasminogen activator; NIHSS, National Institutes of Health Stroke Scale; INR, international normalized ratio; FDA, Food and Drug Administration; and PT, prothrombin time.

administered to adult patients with acute ischemic stroke within 3 hours of onset of symptoms. These results are obtained when rtPA is administered by physicians in hospitals with a stroke protocol that rigorously adheres to the eligibility criteria and therapeutic regimen of the NINDS protocol. These results have been supported by a subsequent 1-year follow-up study,[73] reanalysis of the NINDS data,[74] and a meta-analysis.[75] Evidence from prospective randomized studies[9,15,74,76] in adults also documents a greater likelihood of benefit the earlier treatment is begun. Additional analyses of the original NINDS data by an independent group of investigators confirmed the validity of the results,[74] verifying that improved outcomes in the rtPA treatment arm persist even when imbalances in the baseline stroke severity among treatment groups is corrected.[77]

Treatment of carefully selected patients with acute ischemic stroke with IV rtPA between 3 and 4.5 hours after onset of symptoms has also been shown to improve clinical outcome, although the degree of clinical benefit is smaller than that achieved with treatment within 3 hours.[16,78] Data supporting treatment in this time window come from a large, randomized trial (ECASS-3) that specifically enrolled patients between 3 and 4.5 hours after symptom onset, as well as a meta-analysis of prior trials. Criteria for inclusion in ECASS-3 were similar to the NINDS criteria, except that ECASS-3 excluded patients older than 80 years of age, with a baseline NIHSS >25, taking oral anticoagulants, or who had a combination of diabetes and prior stroke. At present, use of IV rtPA within the 3- to 4.5-hour window has not yet been FDA approved, although it is recommended by a current AHA/ASA science advisory.[78] Administration of IV rtPA to patients with acute ischemic stroke who meet the NINDS or ECASS-3 eligibility criteria is recommended if rtPA is administered by physicians in the setting of a clearly defined protocol, a knowledgeable team, and institutional commitment (Class I, LOE B).

It is important to note that the superior outcomes reported in both community and tertiary care hospitals in clinical trials of rtPA may be difficult to replicate in hospitals with less experience in, and institutional commitment to, acute stroke care.[79,80] Failure to adhere to protocol is associated with an increased rate of complications, particularly the risk of symptomatic intracranial hemorrhage.[79,81] There is a relationship between violations of the NINDS treatment protocol and increased risk of symptomatic intracerebral hemorrhage and death.[71] In Germany there was an increased risk of death after administration of rtPA for acute ischemic stroke in hospitals that treated ≤5 patients per year, suggesting that clinical

experience is an important factor in ensuring adherence to protocol.[72] Adding a dedicated stroke team to a community hospital can increase the number of patients with acute stroke treated with fibrinolytic therapy and produce excellent clinical outcomes.[82] There is also strong evidence to avoid all delays and treat patients as soon as possible. These findings show that it is important to have an institutional commitment to ensure optimal patient outcomes.

Evidence from 3 prospective randomized studies in adults and a meta-analysis[83–87] have demonstrated improved outcome from intra-arterial fibrinolysis. Thus, for patients with acute ischemic stroke who are not candidates for standard IV fibrinolysis, administration of intra-arterial fibrinolytics is reasonable (Class I, LOE B). To date, intra-arterial administration of fibrinolytics has not been FDA approved. In carefully selected patients, catheter-based thrombectomy is being performed at centers where resources and expertise are available. The pending ASA acute ischemic stroke guidelines will provide greater detail about intra-arterial strategies.

General Stroke Care

Recent studies establish that stroke unit care is superior to care in general medical wards, and the positive effects of stroke unit care can persist for years. The benefits from treatment in a stroke unit are comparable to the effects achieved with IV rtPA. Patients should be admitted to a stroke unit (if available) for careful observation (Box 11), including monitoring of blood pressure and neurologic status and physiologic optimization. General stroke care, centered on physiologic optimization, includes prevention of hypoxia, management of hypertension, optimal glucose control, maintenance of euthermia, and nutritional support. Additional efforts center on prevention of complications associated with stroke (eg, aspiration pneumonia, deep venous thrombosis, urinary tract infections) and initiation of secondary stroke prevention.

Given the requirements for frequent neurologic assessment and vital sign measurements, especially after administration of IV rtPA, patients should be admitted as quickly as possible, ideally within 3 hours from arrival.[8] If the patient's neurologic status deteriorates, an emergent CT scan is required to determine if cerebral edema or hemorrhage is responsible for the deterioration. Treatment of hemorrhage or edema should be started immediately as indicated.

Blood Pressure Management

Blood pressure management varies depending on whether or not fibrinolytic or intra-arterial therapies were used. Current recommendations for control of blood pressure in patients who receive IV rtPA or intra-arterial recanalization therapies are shown in Table 2. In those patients for whom recanalization is not planned, more liberal acceptance of hypertension is recommended, provided no other comorbid conditions require intervention (Table 3). Normal saline, administered at a rate of approximately 75 to 100 mL/h, is used to maintain euvolemia as needed. In stroke patients who may be relatively hypovolemic, careful administration of IV normal saline boluses may be appropriate.

Glycemic Control

Hyperglycemia is associated with worse clinical outcome in patients with acute ischemic stroke,[88–95] but there is no direct evidence that active glucose control improves clinical outcome.[96,97] There is contradictory evidence for the benefit of insulin treatment of hyperglycemia in other critically ill patients.[98,99] Current AHA/ASA recommendations call for the use of insulin when the serum glucose level is greater than 185 mg/dL in patients with acute stroke (Class IIa, LOE C); however, the utility of administration of IV or subcutaneous insulin to lower blood glucose in patients with acute ischemic stroke when serum glucose is ≤185 mg/dL remains uncertain.

Temperature Control

Hyperthermia in the setting of acute cerebral ischemia is associated with increased morbidity and mortality and should be managed aggressively (treat fever >37.5°C [99.5°F]).[100–103] Hypothermia has been shown to improve survival and functional outcome in patients following resuscitation from ventricular fibrillation (VF) sudden cardiac arrest; however, there are limited data on the role of hypothermia specific to acute ischemic stroke. At this time there is insufficient scientific evidence to recommend for or against the use of hypothermia in the treatment of acute ischemic stroke (Class IIb, LOE C).

Dysphagia Screening

All patients with stroke should be screened for dysphagia before they are given anything by mouth. A simple bedside screening evaluation involves asking the patient to sip water from a cup. If the patient can sip and swallow without difficulty, the patient is asked to take a large gulp of water and swallow. If there are no signs of coughing or aspiration after 30 seconds, then it is safe for the patient to have a thickened diet until formally assessed by a speech pathologist. Medications may be given in applesauce or jam. Any patient who fails a swallow test may be given medications such as aspirin rectally or, if appropriate for the medication, intravenously, intramuscularly, or subcutaneously.

Other Stroke Management

Additional stroke care includes support of the airway, oxygenation and ventilation, and nutritional support. Seizure prophylaxis is not recommended, but for patients who experience a seizure, administration of anticonvulsants is recommended to prevent more seizures.[104] In patients with severe stroke, posterior circulation stroke, and in younger patients, healthcare providers must observe for signs of increased intracranial pressure.

Summary

Advances in stroke care will have the greatest effect on stroke outcome if care is delivered within a regional stroke system designed to improve both efficiency and effectiveness. The ultimate goal of stroke care is to minimize ongoing injury, emergently recanalize acute vascular occlusions, and begin secondary measures to maximize functional recovery. These efforts will provide stroke patients with the greatest opportunity for a return to previous quality of life and decrease the overall societal burden of stroke.

Disclosures

Guidelines Part 11: Stroke: Writing Group Disclosures

Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Ownership Interest	Consultant/ Advisory Board	Other
Edward C. Jauch	Medical University of South Carolina-Professor	NIH trials related to stroke	None	None	None	None	None
Brett Cucchiara	University of Pennsylvania–Assistant Professor of Neurology	†NIH RO1-migraine imaging research-significant	None	*Multiple CME talks at different institutions	None	None	*Occasionally serves as expert witness for medicolegal cases
Opeolu Adeoye	University of Cincinnati–Assistant Professor of Emergency Medicine and Neurosurgery	None	None	*Genentech EKR Therapeutics	None	None	None
William Meurer	University of Michigan–Assistant Professor	None	None	None	None	None	None
Jane Brice	University of North Carolina: Associate professor in the department of emergency medicine. Perform clinical work in the emergency department. Perform research in the areas of EMS and stroke. Teach in the School of Medicine–Associate Professor	None	None	None	None	None	None
Yvonne (Yu-Feng) Chan	The Mount Sinai School of Medicine–Assistant Professor of Emergency Medicine	None	None	None	None	None	None
Nina Gentile	Temple University–Professor, Department of Emergency Medicine	†Active Support: 5 NIH U01 NS044876–03. Insulin Resistance Intervention after Stroke (IRIS) Trial. Investigation of the effect of Pioglitazone on development of diabetes and stroke recurrence after ischemic stroke or TIA. Total Award to Temple, direct costs: $184,000 2005–2010 NIH NINDS U01 NS40406-04 Albumin in Acute Ischemic Stroke (ALIAS) Trial. Human Serum Albumin will be compared to placebo on improving the 3 month outcome of ischemic stroke patients when administered within 5 hours of symptom onset. Total Award to Temple, direct costs: $225,000 2008–2011	None	None	None	None	None
Mary Fran Hazinski	Vanderbilt University School of Nursing—Professor; AHA ECC Product Development–Senior Science Editor †Substantial consulting fees as a senior science editor for the AHA ECC Product Development.	None	None	None	None	None	None

This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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