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## Abbreviations

ABC	Airway breathing, circulation
AIS	Acute ischemic stroke
BP	Blood pressure
CPSS	Cincinnati Prehospital Stroke Scale
CT	Computed tomography
ED	Emergency department
EMS	Emergency medical services
IA	Intra-arterial
IVDA	Intravenous drug abuse
LAMS	Los Angeles Motor Score
MCA	Middle cerebral artery
NIHSS	National Institutes of Health Stroke Scale
NPO	Nothing by mouth
rtPA	Recombinant tissue plasminogen activator

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Though improved prevention and early treatment of stroke have markedly reduced the morbidity and mortality of cerebrovascular disease, it remains a significant health and social burden. Within the past decade, stroke dropped from the third to the fourth leading cause of death in the USA and in 2012 alone the mortality rate for stroke dropped by 2.6 % and yet it remains a leading cause of adult disability. Economically, the cost of stroke is crippling, both in direct costs and lost opportunity. The global circumstances of stroke are even direr—in many countries it is the second leading cause of death, and the incidence of stroke is projected to double by 2030. To make an impact on this growing societal epidemic, the health-care community must continue to improve our prevention and overall management of stroke.

Fortunately, health-care professionals involved in stroke care can learn from other clinical situations and the successful development of systems of care. For medical conditions where timely identification, transport, and intervention may mean the difference between life or death, integrated systems of care, including prehospital care coordinated with regional hospital services, save lives [1]. Outcome data clearly show the benefits of such systems of care for trauma and ST-segment elevation myocardial infarction (STEMI). More recently, data from similar systems of care for stroke suggest improved outcomes and less morbidity.

## Case Presentation: A 911 Call for Ill Person at Wal-Mart

*Details of the case:* The regional 911-communication center receives a call regarding an ill person at Wal-Mart. The security person tells the dispatcher that an employee was found on the ground between aisles where she was stocking shelves. Currently the employee is unable to speak and is looking to her left. After asking the baseline questions the dispatcher recognizes that this could be a potential stroke and turns to the Emergency Medical Dispatch guide for possible stroke and asks several key questions.

*“Is the patient alert?”*

She is awake but not talking or moving her right side  
*“Can the patient answer your questions?”*

No she just looks to the left and does not follow my commands

*“Does the patient have any medical problems?”*

I don’t know her but her coworkers say she has diabetes and high blood pressure

*“When was the patient last seen normal?”*

A fellow employee had seen her 15 min earlier and noticed no issues.

Based on these responses the 911 dispatcher assigns a high priority ALS response.

## Prehospital Stroke Management

Ideally, prehospital management begins when patients or bystanders recognize stroke signs and symptoms and call 911, but rapid assessment and transport are of little utility if the patients do not arrive at the appropriate hospital within treatment windows. With that in mind, the American Stroke Association (AHA) has developed the stroke chain of survival (Detection, Dispatch, Delivery, Door, Data, Decision, Drug), where the initial links focus on stroke recognition and EMS engagement. Community education on stroke symptoms and early EMS access are critical components of any regional stroke system. Most recently the message of think “FAST” is being used to educate the public on stroke. The presence of Facial droop, Arm weakness, or difficulty with Speech could represent ongoing stroke, and thus should prompt people to act FAST and call 911 for the sake of Time. While some educational programs have successfully increased awareness of stroke symptoms, the majority of patients still miss the treatment window [2]. Clearly, continued public education is key.

## 911 Activation

Once 911 is activated, stroke recognition is essential. With the advent of Emergency Medical Dispatch tools and the use of dispatcher protocols, patients with stroke-like symptoms are more easily recognized by 911 operators. However, there is variability in dispatcher ability to recognize stroke symptoms, with correct identification varying between 30 and 83 % [2]. Any patient presenting within a 6–8 h window of symptom onset should still be considered a candidate for acute intervention and appropriate response configurations utilized. Use of protocols clearly helps determine dispatch prioritization, which is critical to potential early interventions [3].

There are many barriers to treatment, primarily related to delays in hospital arrival after symptom onset [4]. Patients that do not use 911 or EMS, have a prior stroke history or mild symptoms, or are ethnic minorities or live in rural communities, all have lower rates of reperfusion treatment [5–7]. Patients are more likely to receive timely treatment if they

utilize 911, are transported by EMS, have more severe symptoms, or have a new stroke. Most importantly for prehospital providers, early EMS notification to the receiving hospital makes timely treatment more likely. Identifying and addressing any regional prehospital barriers to care is critical to ensuring optimal care.

## Case Presentation: A 911 Call for Ill Person at Wal-Mart

On arrival the EMS personnel find the patient lying on the ground, awake but not talking. A quick assessment shows no imminent issues regarding the patient’s airway, breathing, or circulation (ABC’s). Her initial vital signs are blood pressure of 175/110 mmHg, pulse rate of 93 and irregular, oxygen saturation of 92 % on room air.

EMS personnel quickly perform the Cincinnati Prehospital Stroke Screen that is positive since the patient is aphasic, has a facial droop on the right and is unable to move her right arm. EMS personnel also ask coworkers about when she was last normal, was she complaining of anything prior to the onset, and if she has any medical problems. EMS asks Wal-Mart staff to bring her purse in which they find medications for diabetes and blood pressure. Given the high suspicion for stroke they quickly prepare the patient for transport to the most appropriate stroke center.

## Prehospital Stroke Assessment

As with all initial assessments, the first priorities are the ABCs. The airway should be assessed in standard fashion, but note that stroke patients may have difficulty managing their secretions and could be prone to vomiting. If possible, the head of the stretcher should be elevated to 30°. However, if the patient symptoms worsen with the head of the bed elevated, the patient’s head should be placed back to flat since the patient may require the higher blood pressure to perfuse the area of stroke. Typically for most stroke patients, breathing is not substantially altered, but if it is, ventilatory assistance is warranted. Hyperventilation should be avoided unless the patient’s presentation suggests impending herniation (i.e., has signs of hypertension, bradycardia, irregular respiratory pattern) and is approved by medical control. Circulatory status is assessed with vital signs and ECG monitoring, as stroke patients are at risk for dysrhythmias. Frequent reassessment of the ABC’s is required as the patient’s condition may dramatically change en route.

After the primary survey and baseline vitals, performance of a validated stroke assessment tool aids in the recognition of possible stroke. There are a variety of scales that are widely used, but the most common are the Cincinnati Prehospital Stroke Scale (CPSS) and the Los Angeles Motor Scale (LAMS) (Table 2.1) [2]. These screening tools attempt to balance ease of use with accuracy in order to help identify the

**Table 2.1** Prehospital stroke scales

Cincinnati Prehospital Stroke Scale [19]		Los Angeles Motor Scale (LAMS) [20, 21]		
Face	Both sides move normally	Face	0	Both sides move normally
	One side is weak or is flaccid		1	One side is weak or flaccid
Arm	Both arms have equal normal strength	Arm	0	Both sides move normally
	One arm is weak or does not move at all		1	One side is weak
Speech	Speech is normal and appropriate		2	One side is flaccid/does not move
	Speech is slurred, inappropriate words or mute	Grip	0	Both sides move normally
If any one of these is abnormal then there is a 88 % sensitivity for anterior circulation stroke	1		One side is weak	
	2		One side is flaccid/does not move	
	Total	0–5		
LAMS score closely correlated with full NIHSS. LAMS ≥ 4 carries an over sevenfold increase in risk for large vessel occlusion				

NIHSS National Institutes of Health Stroke Scale

**Table 2.2** Conditions with stroke-like symptoms (mimics)

Stroke mimic	Historical features	Clinical features
Bell's palsy	Recent viral illness, history of previous Bell's palsy	Upper and lower facial muscles involved. No other neurologic deficit
Complicated migraine	History of migraines; aura/headache preceding onset of neurologic symptoms	Headache, may have focal neurologic deficits or more global deficits
Conversion disorder/Psychogenic	History of psychiatric disorders; recent stress	No cranial nerve findings; neurologic deficits do not fit a vascular distribution; exam changes with time
Hypertensive encephalopathy	History of hypertension	Hypertension, headache, altered level of conscious, seizure
Hypoglycemia	Known diabetic	Low glucose, decreased level of consciousness
Infection/Abscess	History of IVDA, endocarditis	Altered mental status; fever
Seizures	History of seizures; witnessed seizure	Loss of consciousness; tongue biting
Tumor	Known malignancy	Slow onset of symptoms; seizure at onset

IVDA intravenous drug abuse

presence of neurologic impairment, but they have some limitations. First, the gross motor exams utilized can miss subtle strokes. Conversely, most of these scales fail to grade the severity of the stroke, which may have implications in selecting an appropriate destination facility. Second, these scales may suggest a stroke when another cause of the patient's symptoms exist, conditions termed "mimics" (Table 2.2). Stroke mimics may account for more than 20 % of patients with neurologic symptoms in the prehospital setting being considered as an acute stroke [8]. While it is impossible to exclude all stroke mimics in the prehospital setting, a basic understanding of mimics should prompt providers to ask pertinent questions of the patient or family, which may lead to more effective patient care. Regardless of the stroke tool used, providers should always consider stroke mimics in their differential but should err on the side of treating the patient as a stroke.

The process of stroke identification in the prehospital setting is constantly evolving as stroke treatments become more advanced. Efforts are underway to not only identify patients having a stroke but to consider stroke severity and time from symptom onset in order to triage a stroke patient to the most

appropriate receiving facility and to provide important prearrival information to the stroke team. More comprehensive, graded exams may help to identify and quantify specific stroke characteristics that assist the stroke team in determining treatment options. There are also online and smartphone applications that are available for these scales. Unfortunately, these scales are more time consuming and may be more difficult to remember than the earlier stroke assessment tools, but in conjunction with a good patient history, the newer scales can provide a clearer picture of the patient's condition.

The patient's medical history is another crucial part of the assessment. Past medical history, including relevant surgeries, medications, and allergies, are critically important and should be documented appropriately. Particular attention should be paid to potential stroke risk factors, such as atrial fibrillation, hypertension, diabetes, previous strokes, transient ischemic attacks, recent surgeries, and smoking [9]. One of the most important elements of the patient's history is the time of symptom onset, which will dictate many treatment options. The time of onset is based on the last time the patient was known to be "normal" or at their baseline, as

opposed to when the patient was found with the neurologic deficits. It is also important to document the patient's baseline physical and mental state, especially for patients with previous neurologic, physical, or cognitive deficits. To determine last "normal" time, the patient and family members, caregivers or bystanders should be interviewed. If they are unsure about a specific time, inquiry about other time clues such as daily routines, television shows, or recent phone conversations may be helpful [9]. This can help narrow the time window of symptom onset. Other onset factors to consider include activity, headache, trauma, and seizures. These conditions provide clues to the presence of mimics but may also suggest the possibility of intracranial hemorrhage.

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As they prepare for transport the EMS providers follow their "Suspected Stroke" protocol. They initiate an IV in the left antecubital fossa as requested by the local stroke center, assess her blood glucose, which was 150 mg/dL, and provide supplemental oxygen by nasal cannula, to maintain saturation above 94 %. The initial tracing on the cardiac monitor shows atrial fibrillation with a ventricular rate in the 90s. While her repeat blood pressure is 180/107 mmHg they do not initiate any antihypertensive therapies. Since the last known normal time was less than an hour ago, the patient is triaged to the nearest stroke center. En route, EMS personnel contact the receiving hospital and provide preliminary information regarding what they suspect to be a patient suffering a large stroke.

### Prehospital Transport

Once the assessment and history are complete, prehospital focus should be on rapid initiation of treatment and transport. On scene time should be less than 15 min whenever possible and the patient should be treated with the same

urgency as major trauma or STEMI [9]. The management plan includes frequent reassessment and management of the ABCs, as well as vital signs and cardiac and pulse oximetry monitoring (Table 2.3). Oxygen should be applied to maintain an SpO<sub>2</sub> above 94 %, though supplemental oxygen is not recommended in nonhypoxic patients with acute ischemic stroke [9]. Finger stick blood glucose assessment is essential in all patients with stroke-like symptoms and hypoglycemia should be corrected with intravenous dextrose per protocol.

Other emergent interventions are rarely required in the prehospital setting, unless the patient begins to decompensate with airway or ventilatory compromise, cardiac dysrhythmias or hemodynamic instability. Currently, no evidence exists to support prehospital lowering of blood pressure in hypertensive stroke patients, and in some cases lowering blood pressures to "normal" levels could exacerbate the patient's symptoms. Prehospital administration of aspirin or other antithrombotic agents to potential stroke patients is also not supported by published studies at this time.

Once EMS has assessed the patient and initiated appropriate management, prompt triage and transport to the most appropriate stroke center destination are critical for effective stroke treatment. As previously mentioned, patient outcomes are better if they are treated at a stroke center, though bypassing the closest facility for a higher level of care should not extend transport time more than 15–20 min [4]. In urban areas, this may be easier to achieve, though traffic patterns and distance may still be considerations. Suburban or rural EMS agencies may have more difficulty accessing a stroke center, though this demonstrates why a regional stroke system concept is so important. Use of helicopter transport increases access to thrombolytics for patients residing in communities that lack specialty facilities and should be utilized when necessary [10–12]. If the patient is too unstable for a prolonged transport or a helicopter is not available, transport to the closest facility for rapid assessment, stabilization and preparation for transfer to a stroke center is an appropriate alternative.

**Table 2.3** AHA recommendations for prehospital management of potential stroke [9]

Recommended	Not recommended
ABC's—assess and reassess	Do not treat hypertension unless directed by medical command
Perform cardiac monitoring	
Provide oxygen to maintain oxygen saturation >94 %	
Perform blood glucose assessment, treat if <60 mg/dL	Do not treat with oral medication; maintain strict NPO
Establish intravenous access (consider antecubital 18 gauge)	Do not administer excess fluid or glucose containing solutions
Determine last known normal time	
Determine past medical history and any recent events	
Obtain family contact and phone number	
Triage to most appropriate regional stroke hospital	Do not delay transport for interventions
Provide prehospital notification en-route	
Obtain feedback/Quality improvement	

ABCs airway, breathing, circulation, NPO nothing by mouth

Regardless of destination facility or mode of transport, early EMS notification of the receiving hospital is critical. Prehospital notification has been clearly shown to reduce ED times to definitive treatment [2]. In addition to customary information, reports should include “last known normal” time, stroke scale results, vital signs, blood glucose, and any other interventions. Close monitoring of patient condition during transport is obviously critical, and significant patient deterioration should prompt consideration of diversion to a closer facility.

#### **Case Presentation: A 911 Call for Ill Person at Wal-Mart**

On arrival at the stroke center Emergency Department, EMS providers are met by the Emergency Department physician and members of the stroke team. After a quick verification of the ABC's the EMS personnel go straight to the CT scanner and provide report. As they complete their run report, they are shown the patient's CT scan that demonstrates no sign of intracerebral hemorrhage but there is a hyperdense middle cerebral artery (MCA) on the left, consistent with their suspicion of a large left MCA stroke. Later, the EMS crew returns to the hospital and learns the patient received IV rtPA and intra-arterial thrombectomy with successful reperfusion within 2 h of last known normal time.

### **Emergency Department Stroke Management**

Emergency Department (ED) management of stroke patients parallels prehospital management. With the critical prehospital notification, all the necessary components of the hospital-based stroke team can be at bedside prior to patient arrival. A rapid assessment of the ABCs on arrival allows for most patients to be taken directly to the CT scanner by EMS, significantly reducing imaging delays. Prehospital notification, concurrent physical evaluation, diagnostic testing, and medical history review substantially reduce time to intervention, the so called Door-to-Needle time, to less than the currently recommended 60 min [13]. A recent study of 58,353 patients treated with IV rt-PA clearly demonstrated the importance of lowering time to treatment, finding that “among 1,000 treated patients, every 15-min-faster acceleration of treatment was associated with 18 more patients having improved ambulation at discharge ... and 13 more patients being discharged to a more independent environment (including 7 more being discharged to home)” [14].

### **Interhospital Transfers**

Even with aggressive community and EMS education and advanced protocols, patients will present to facilities that are unable to manage acute stroke, or patients may require more advanced stroke care than is available at the original hospital.

The “drip and ship” practice—assessing a patient and initiating thrombolytics before transfer to a higher level of care—may be an appropriate treatment choice for patients presenting within the therapeutic window [4]. EMS and transport providers involved in such interhospital patient transfers should carefully monitor vital signs and the neurologic exam. Strict blood pressure control, maintaining blood pressure below 180/105 mmHg, is required after thrombolytics and clinical deterioration may indicate an intracranial hemorrhage. Air medical transport has been shown to be safe and effective, including for those patients who have received thrombolytics [15]. As with field transport of stroke patients, early destination hospital notification is critical. Preplanning of the transfer process is key to minimizing delays when a stroke patient requires transfer to a higher level of care.

### **Future of Prehospital Stroke Care**

Neurologic emergencies will always be time sensitive, and as such, traditional hospital-based strategies are now being evaluated in the prehospital setting, including novel diagnostic tools, directed therapies, and physiologic management. Prehospital traumatic brain injury physiologic management and early treatment of active seizures are examples where field initiation of global and targeted therapies makes a demonstrable difference on patient outcomes [16].

To further minimize delays to treatment, some centers in the USA and Europe are equipping ambulances with mobile CT scanners, video telemetry, and in some cases neurologists, to respond to the scene of a potential stroke. This model employed in a study by Audebert and colleagues in Berlin led to a reduction in call to needle time of 36 min [17]. Similar models are now being studied in Houston, TX, and Cleveland, OH. This high tech, resource intensive approach may not be broadly applicable in more rural areas but demonstrates the growing appreciation for incorporating the prehospital setting into acute treatment paradigms.

No drug or therapy administered in the prehospital setting has been shown to improve patient outcomes, but recent studies show early treatment is feasible. In acute stroke, the recently completed FAST-Mag study of prehospital administration of magnesium failed to show clinical benefit but demonstrated that patients could be appropriately identified as having a potential stroke and a therapeutic agent, magnesium, administered in a safe and timely fashion [18]. Future studies of prehospital interventions may one day produce successful EMS-administered therapies.

### **Summary**

Stroke is a time-dependent emergency and prehospital involvement is crucial for maximizing patient outcomes. Coordinated development of regional resources into a



cohesive stroke system of care is the cornerstone of stroke care. Early EMS activation, stroke identification, prehospital management, and rapid transport and triage to the most appropriate stroke center will give the patient the best chance to make a full recovery.

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Ischemic Stroke Therapeutics

A Comprehensive Guide

Ovbiagele, B.; Turan, T.N. (Eds.)

2016, XIII, 322 p. 89 illus., 49 illus. in color., Hardcover

ISBN: 978-3-319-17749-6