

# EMS MANAGEMENT OF ACUTE STROKE— PREHOSPITAL TRIAGE (RESOURCE DOCUMENT TO NAEMSP POSITION STATEMENT)

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ABSTRACT

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## INTRODUCTION

Stroke is the third leading cause of death and the leading cause of adult disability in the United States.<sup>1</sup> Roughly one American suffers a stroke every minute, and one American dies of stroke every 3.5 minutes.<sup>2</sup> In 1995, the National Institute of Neurological Disorders and Stroke (NINDS) study showed that intravenous administration of tissue plasminogen activator (tPA) had clinical benefit for a select group of patients with acute ischemic stroke. Most importantly, patients maximally benefit from intravenous administration of tPA if treatment is started as soon as possible within 3 hours of symptom onset.<sup>3–6</sup>

In addition to intravenous fibrinolysis, emerging endovascular therapies have shown promise or have received FDA approval as treatments for stroke in early time windows. Intra-arterial fibrinolysis within 6 hours of onset of middle cerebral artery infarction improved outcome in a randomized phase 3 trial.<sup>7</sup> Endovascular mechanical embolectomy with the MERCI Clot Retriever within 8 hours of onset showed technical success in achieving recanalization and was approved by FDA in 2004 for the restoration of blood flow in the neurovasculature in patients experiencing acute ischemic stroke.<sup>8,9</sup> Other therapies are also likely to be time dependent because the viability of ischemic brain tissue diminishes rapidly with time. This would be the

case for not only specific pharmacological or interventional therapy targeting reperfusion, neuroprotection, and limitation of bleeding but also for blood pressure control, correction of hyper- or hypoglycemia, and reversal of hypoxemia.

The narrow therapeutic window of stroke therapy has important implications for emergency medical services (EMS) system operation. EMS professionals must be proficient in their ability to recognize, assess, manage, treat, triage, and transport stroke patients. On the basis of a review of the literature, we make the following recommendations for the prehospital triage of stroke patients.

## DISCUSSION

### Expeditious EMS Dispatch and Response

An EMS response begins with the dispatch priority level. Because approved treatment for acute stroke must be initiated rapidly, dispatches for suspected stroke patients should be expedited.<sup>10–14</sup> Consequently, the prehospital response to a suspected acute stroke patient should always assume that a therapeutic window for treating an ischemic stroke is closing.

EMS transport to and arrival at the emergency department increases the odds that a patient will present within the 3-hour time window, compared to private physician referral and self-transport,<sup>15</sup> and significantly reduces the time from symptom onset to CT evaluation.<sup>16–20</sup> These findings imply that patients and their family members who suspect development of acute stroke should be encouraged to use EMS to expedite care. Unfortunately, the general public has limited understanding of the signs and symptoms of stroke.<sup>21–25</sup> Therefore, the burden of suspecting stroke is often transferred to EMS dispatchers. By providing additional guidance to EMS dispatchers to encourage appropriate questioning of callers to public safety answering points, the possibility of acute stroke may be recognized and aid sent quickly.

Patients with ischemic stroke and hemorrhagic stroke often have similar signs and symptoms, yet they require very different treatment. Only computerized tomography (CT) or magnetic resonance imaging (MRI) of the brain interpreted by an appropriately trained physician can determine whether the stroke is ischemic or hemorrhagic in etiology and guide appropriate selection of therapies.

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## Prehospital Stroke Screening and Patient Assessment

Early identification of stroke symptoms by emergency medical personnel is a valuable part of optimal care for victims of stroke. To optimize stroke identification in the field, prehospital professionals should be competent in the use of a prehospital stroke screening instrument that has been prospectively evaluated for sensitivity, specificity, reproducibility, and validity.<sup>27–30</sup>

The sensitivity of paramedic identification of stroke patients unaided by a formal screening algorithm has varied between 61% and 72%.<sup>27,31</sup> However, the use of a prehospital stroke assessment instrument has been shown to markedly increase paramedic sensitivity to stroke identification in the field. Two common prehospital stroke instruments, the Los Angeles Prehospital Stroke Screen (LAPSS) and the Cincinnati Prehospital Stroke Scale (CPSS), have both demonstrated sensitivities of greater than 90%.<sup>29,32,33</sup> In addition, the more recent Melbourne Ambulance Stroke Screen (MASS), which is an amalgamation of the CPSS and LAPSS, has also shown a sensitivity of 90%.<sup>33,34</sup>

Some studies have shown that EMS dispatchers may be trained to a modified stroke identification instrument, which can be effective in optimizing stroke care.<sup>35–38</sup> EMS personnel should be familiar with a technique of prehospital stroke assessment and use it routinely on patients suspected of having a stroke. Prehospital care providers should be capable of incorporating their prehospital stroke findings with the patient's signs, symptoms, and risk factors to make a final stratification of stroke likelihood.<sup>39</sup>

EMS professionals should attempt to determine the time of onset of the patient's neurological symptoms and the time the patient was last known to be symptom free. EMS professionals frequently have access to historical and medical information from family members, caregivers, or bystanders that may not be immediately available when the patient arrives in the emergency department. Time of onset is an essential component of prehospital stroke screening instruments and may be a factor in determining triage and transport modality decisions (see air medical transport of stroke patients). The onset time is based on when the patient was last seen at his or her normal or baseline level of function. Without a clear time of symptom onset, most recanalization (intravenous tPA) strategies may be precluded.<sup>28,29,40</sup>

Furthermore, EMS providers should have specific basic knowledge of, and document the proper use of, important principles of stroke management as embodied in acute stroke guidelines,<sup>5,11–13</sup> such as treatment of glucose and hypoxia.

Despite the importance of identifying stroke in the field, stroke-related subject matter has been given scant attention in the Department of Transportation's (DOT) National Standard Curriculum for all Emergency Med-

ical Service personnel. However, didactic material pertaining to stroke has been included in the majority of the most popular textbooks and reference materials for EMS providers. Furthermore, many of the handbooks and training manuals used in first responder training programs include a detailed coverage of stroke.

## Communication with Receiving Facilities

Previous studies on the prehospital management of acute myocardial infarction have shown that prehospital notification of impending patient arrival can reduce the time to reperfusion treatment.<sup>41–43</sup> Similarly, early EMS notification of an in-bound stroke patient can provide significant preparation time to hospital personnel.<sup>44</sup> Physicians, nurses, CT/MR technologists, pharmacists, and others are able to use early notification to mobilize necessary resources for the patient.<sup>5,45,46</sup> Prehospital notification of in-bound stroke has been demonstrated to shorten delays from ED arrival until initial neurological assessment and initial brain imaging, and to increase the proportion of patients treated with reperfusion therapy, both as an individual intervention,<sup>18,19</sup> and as one element in the implementation of a comprehensively organized prehospital stroke care system.<sup>25,47–50</sup>

## Local/Regional Strategies for Stroke Patient Destination

Several factors are important in determining a hospital's capability in providing emergent stroke care. Some of these important factors include (1) the presence of physicians with expertise in the diagnosis and management of stroke and head CT and/or MRI interpretations, (2) the availability of essential brain imaging capacity (CT or MRI) and adequate emergent ancillary care, and (3) the availability of knowledgeable personnel to carry out approved stroke therapies including the use of IV-rtPA, and (4) the presence of an institutional plan to handle, or at least provide initial evaluation of, primary hemorrhages and hemorrhagic transformation of cerebral infarcts.<sup>51</sup> It is unreasonable to expect all hospitals (urban, suburban, and rural) to provide this level of care for patients with stroke on a 24-hour basis. However, any limitations in the availability of these important factors should be incorporated into the regional protocol for triaging acute stroke patients in the prehospital setting and agreed upon by the stakeholders. The stakeholders for developing such protocols should include (but are not limited to) EMS personnel, EMS medical directors, emergency physicians, neurologists, radiologists, neurosurgeons, and stroke patients. Many state health departments and EMS agencies in collaboration with the American Heart Association/American Stroke Association are working with these stakeholders to facilitate the development of these protocols.

Previous research has documented the improved outcome of patients who receive in-hospital care at facilities specializing in stroke care.<sup>52–54</sup> In addition, transporting patients to a center with immediate access to stroke expertise and willingness to treat has been shown to increase tPA use.<sup>25,47</sup> Lattimore also found that becoming a stroke center increased tPA use.<sup>55</sup> These findings suggest that bypass of facilities unable to reliably provide basic stroke care in favor of primary stroke center facilities capable of providing this care may increase the number of patients treated with thrombolytic therapy and thus promote better patient outcomes, when resultant additional travel times and system burden are not too great.

The Joint Commission on Accreditation of Healthcare, nationally, and several state Departments of Health, regionally, now provide credentialing for hospitals that meet minimum criteria for carrying out acute stroke care. These are being adopted by some state legislatures to foster statewide stroke triage plans (New York, Massachusetts, Michigan, Florida, Texas, New Jersey, New Mexico, and others). Prehospital stroke triage policies should address time variables (interval between symptom onset and EMS evaluation), distance variables (transport distance to available health care facilities), and available stroke care capabilities in the region.

Because almost half of all acute stroke patients will not use EMS to access health care, it is important that all emergency departments develop plans to quickly assess and treat victims of stroke. It may be useful to secondarily transfer stroke patients to a regional stroke unit regardless of the age, size, or severity of the stroke as well as the administration (or lack thereof) of fibrinolytic therapy. Any protocols with respect to secondary transfers to regional stroke units should be developed with EMS operational and medical direction involvement to ensure timely transport by appropriate EMS personnel.

### Emerging Alternative: Air Medical Transport

In remote geographical areas without nearby hospital facilities, the use of air medical transport from the field to a stroke center or other facility capable of managing acute stroke patients should be considered.<sup>57</sup> Air medical transport may reduce transit times, may increase the availability of thrombolytic therapy to residents of rural communities,<sup>58</sup> and may be cost-effective.<sup>59,60</sup> The air medical evacuation of a stroke patient in the prehospital setting could be considered if both of the following conditions are present:<sup>51</sup>

1. The closest facility capable of providing treatment to the patient with an acute stroke is more than an hour

away by ground ambulance. Given the current 3-hour window for fibrinolytic therapy, ground transportation for more than 1 hour is likely to preclude intravenous tPA administration. Transport times exceeding 60 minutes could potentially be used more effectively for in-hospital evaluation and supportive care than in transit.

2. The patient can reach a facility providing definitive stroke diagnosis and treatment within the 3-hour therapeutic time window for intravenous thrombolysis, or longer if medically appropriate for other interventions, using air medical transport.

If these conditions cannot be achieved, then prehospital triage should be determined by the guidelines set forth above, and the patient should be transported to the nearest hospital for initial assessment and stabilization. Secondary interfacility transport to a stroke center, either by ground or air, may follow when feasible if medically appropriate.<sup>60–62</sup>

In any situation where air medical evacuation is necessary, we strongly support prehospital discussion with medical oversight because air transportation may be influenced by weather, availability of personnel and air ambulances, maintenance issues, and other factors that may negate its potential advantage of speed.

In summary, EMS systems should consider developing a policy of transporting acute stroke patients by air if the closest facility capable of treating acute stroke is more than 1 hour away by ground transport, and the patient can reach the facility within the treatment time windows for selected therapies. Because of the many factors that influence the success of air medical transport, future research should examine the factors that are most strongly associated with the optimal use of air medical transport for stroke patients.

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# EMS MANAGEMENT OF ACUTE STROKE— OUT-OF-HOSPITAL TREATMENT AND STROKE SYSTEM DEVELOPMENT (RESOURCE DOCUMENT TO NAEMSP POSITION STATEMENT)

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## ABSTRACT

The American Heart Association estimates an annual incidence of stroke in the United States at 700,000, leading to over 150,000 deaths. Of all strokes, approximately 88% are ischemic and 12% are hemorrhagic. Almost half of all stroke deaths occur in the out-of-hospital environment.<sup>1</sup> Within a given region, the emergency medical services (EMS) system has an important role in the management of the acute stroke patient. Decisions made by EMS personnel can affect treatment and contribute to the immediate, short-term, and long-term outcomes of the patient. Because the patient may require emergent treatment regardless if the stroke is ischemic or hemorrhagic, EMS personnel should manage all potential stroke patients in a time-dependent nature. Proper treatment and disposition of the stroke patient begins in the out-of-hospital environment, continues in the emergency department, and then extends to the inpatient admission. This article reviews the literature on the out-of-hospital treatment of stroke patients and the role of EMS in the development of stroke systems of care. **Key words:** stroke; emergency medical services; systems of care.

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## INTRODUCTION

The American Heart Association estimates an annual incidence of stroke in the United States at 700,000, leading to over 150,000 deaths. Of all strokes, approximately 88% are ischemic and 12% are hemorrhagic. Almost half of all stroke deaths occur in the out-of-hospital environment.<sup>1</sup> If recent trends continue, the 30-year projections suggest a 98% absolute increase in stroke deaths from 139,000 in 2002 to 275,000 in 2032 with a corresponding increase in the U.S. population of only 27%.<sup>2</sup>

Within a given region, the emergency medical services (EMS) system has an important role in the man-

agement of acute stroke patients. Decisions made by EMS personnel can affect treatment and contribute to the immediate, short-term, and long-term outcomes of the patient.

The first step for EMS is the early identification of patients who may be having a stroke. This begins with entry of the patient into the EMS system via “911” or equivalent emergency call centers. Once potential stroke patients have been entered into the EMS system, it then falls to the responsibility of the on-scene EMS personnel to accurately screen and assess potential stroke patients. Because the patient may require emergent treatment regardless if the stroke is ischemic or hemorrhagic, EMS personnel should manage all potential stroke patients in a time-dependent nature.

In 1995, the National Institute of Neurological Disorders and Stroke (NINDS) published a study in which tissue plasminogen activator (t-PA), given within 3 hours of symptom onset, improved outcome for patients with acute ischemic stroke.<sup>3</sup> The NINDS study showed that patients given t-PA were more likely to have minimal or no disability at 3 months compared to placebo (favorable outcome by Barthel index of 50% compared to 38%, respectively; relative improvement of 31.6%). At the same time, however, patients given t-PA were at a statistically significant higher risk for intracerebral hemorrhage within 36 hours than the placebo group at 6.4% compared to 0.6% respectively (increased relative risk of 9.7%).

Over the past 10 years there has been much controversy over the use of t-PA for acute ischemic stroke. Much of this controversy has revolved around protocol violations and the exact subset of patients that are appropriate to receive t-PA.<sup>4,5</sup> Another element of the controversy has been related to the statistical methods used in the NINDS trial. Some authors have argued that the results are not valid due to an imbalance in the study groups.<sup>6</sup> Because of this concern, a group of independent reviewers recently published results on a reanalysis of the findings from the NINDS trial. Their findings reaffirmed support for the use of t-PA to treat patients with acute ischemic stroke within 3 hours of onset of symptoms, despite an increased incidence of symptomatic intracranial hemorrhage.<sup>7,8</sup>

Regardless of the findings from the independent commission, there continues to be only a small fraction of acute stroke patients who are eligible for thrombolytics due to the restrictive inclusion criteria.<sup>9</sup> However,

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beyond the use of intravenous t-PA for the treatment of acute ischemic stroke, there are other treatment modalities that may be beneficial for stroke patients. Many of these additional treatment modalities may be initiated in the out-of-hospital environment and continued in the emergency department and following admission. The ideal agent for field use would be a neuroprotective agent that could be administered during transport.<sup>10,11</sup> However, to date, no neuroprotective agent has been shown to be effective in reducing the morbidity or mortality associated with acute ischemic stroke.

In addition to stroke specific therapies, there are several other treatment measures that should be considered by all EMS personnel when caring for the patient with a potential stroke. These measures include position of patient during transport, use of oxygen therapy and airway management, placement of intravenous lines and administration of intravenous fluids, electrocardiographic monitoring, blood glucose monitoring and correction of hypoglycemia, administration of aspirin, and monitoring of blood pressure derangements. In the emergency department, acute stroke patients should be assessed for potential candidacy for intravenous or intra-arterial t-PA, or neurosurgical consultation for hemorrhagic stroke. Once the patient has been admitted, acute stroke patients should be managed in consultation with a neurologist and assessed for short-term (e.g., fever, blood glucose derangements, blood pressure derangements, aspiration pneumonia, deep venous thrombosis) and long-term (i.e., rehabilitation, psychological health) sequela of stroke.

Recently, two independent groups, the Brain Attack Coalition (BAC) and the American Stroke Association (ASA), a division of the American Heart Association, have developed recommendations for the treatment of stroke patients and the development of stroke centers.<sup>12,13</sup> The recommendation that all acute stroke patients receive treatment at accredited stroke centers has significant implications because many acute stroke patients are transported to acute care centers through the EMS system. The early identification of the potential stroke patient and subsequent transport to an appropriate care facility is the responsibility of the EMS system. Therefore, EMS medical directors should develop regional protocols for the identification and treatment of potential stroke patients and should be involved in the development of any regional stroke systems of care.

## REVIEW OF SUPPORTING LITERATURE

### Out-of-Hospital Screening for Stroke Patients

Because the outcome of some stroke treatments is time dependent, it is important to rapidly enter a patient who is possibly experiencing a stroke into the EMS system. Entry into the EMS system begins with the "911" or

equivalent emergency operator and continues with the EMS personnel that provide direct care to the patient.

For EMS personnel to accurately identify a patient who may be having a stroke, it is valuable to have a screening tool that is easy to perform. Two stroke screening assessments have been documented to have a high sensitivity in identifying patients who may be having a stroke in the out-of-hospital setting: the Cincinnati Prehospital Stroke Scale and the Los Angeles Prehospital Stroke Screen.<sup>14,15</sup> It is recommended that all EMS personnel use a screening tool for the assessment of patients who may be having a stroke.

### Out-of-Hospital Treatment of Stroke Patients

#### Transport Position

The primary aim of acute stroke treatment is to restore blood flow to poorly oxygenated brain tissue. Positioning of the head at zero degrees, or supine, during assessment and transportation may increase arterial blood flow through the effects of gravity. Traditional positioning for most acute neurological conditions has been with 30° of head elevation to decrease intracranial pressure (ICP).<sup>16–18</sup> However, in ischemic stroke patients, ICP does not peak until 48 hours postinfarction, and increased blood flow may be more beneficial in the acute setting.<sup>19,20</sup> Schwartz et al. demonstrated an improvement in cerebral perfusion pressure (CPP) from  $64.7 \pm 1.7$  mmHg with a 30° elevation to  $77 \pm 1.8$  mmHg with a flat position ( $p < 0.001$ ).<sup>21</sup> ICP changes were found to be clinically insignificant. Wojner-Alexandrov et al. demonstrated a 20% improvement in middle cerebral artery (MCA) blood flow in a flat position compared to 30° of head elevation with no detrimental effects noted.<sup>22</sup>

As of this date, there are no published studies that have examined head positioning of stroke patients in the out-of-hospital setting. Furthermore, proper assessment and management of airway, breathing, and circulation are of primary importance in acute stroke. Stroke patients may need stabilization of airway and transportation with aspiration precautions. Therefore, the benefits and risks of flat head positioning in the prehospital setting are unknown at this time, and further studies need to be performed. However, a flat assessment and transport position for patients with acute stroke that have no clinical evidence of elevated ICP and can tolerate positional changes may improve blood flow to the brain.

#### Oxygen

Supplemental oxygen therapy is frequently a routine intervention in the prehospital patient with acute stroke. Decreases in oxygen saturation can lead to worsening of cerebral ischemia.<sup>23</sup> Furthermore,

administration of supplemental oxygen to those that are not hypoxic may improve oxygen supply to ischemic tissue and thereby minimize the ischemic penumbra.

Animal studies have suggested that there may be some benefit to administering 100% supplemental oxygen to nonhypoxic ischemic stroke victims.<sup>24,25</sup> However, human studies that have compared the use of supplemental oxygen to no oxygen therapy for stroke patients have shown no additional improvement of outcomes with oxygen administration.<sup>26,27</sup> The use of hyperbaric oxygen therapy has also been shown to have no benefit in the treatment of stroke.<sup>28</sup> Furthermore, there is some evidence that suggests that hyperoxia may be harmful.<sup>29,30</sup> Currently, the best evidence with regards to the use of oxygen is in the maintenance of homeostasis.<sup>31</sup> Stroke units that have tried to maintain normal oxygen saturation in addition to euglycemia and normothermia have demonstrated the best stroke outcomes.<sup>31–33</sup>

Current recommendations based on available literature are to monitor oxygen saturation continuously with a pulse oximeter and treat hypoxia with supplemental oxygen. Because there is no conclusive evidence that supplemental oxygen for those that are not hypoxic causes harm, clinicians may consider the use of oxygen in stroke for patients who are not hypoxic.<sup>34</sup> However, because the goal of treatment should be to maintain normoxia, supplemental oxygen for those who are not hypoxic should be given at low flow rates. Additional research is needed to determine if there are any benefits or harm from the use of supplemental oxygen in nonhypoxic acute stroke patients.

### IV Access

Since acute stroke should be treated as a time-dependent emergency, rapid transport to a definitive care facility is of utmost importance. Delays in the prehospital setting need to be avoided. One potential time delay relates to the establishment of intravenous (IV) access. A field line may be appropriate for cases when acute resuscitation medications are needed. Otherwise, transportation should be started immediately and IV access secured en route. Although paramedics have demonstrated proficiency at prehospital line placement, attempts prior to transport can lead to increased scene time.<sup>35–37</sup>

In the hospital, intravenous lines are useful for obtaining blood for laboratory tests and for administering medications including contrast agents during imaging. The current imaging gold standard for acute stroke is computed tomography (CT) without contrast to separate hemorrhagic from ischemic stroke.<sup>38,39</sup> Other imaging modalities that are being used with increased frequency include magnetic resonance imaging (MRI) with or without contrast, diffusion weighted imaging

with MRI, CT angiography, and CT perfusion imaging. MRI contrast is administered manually such that the size of the line is not crucial. However, contrast CTs are performed with power injectors that often require IV lines to be large bore and no more distal than the antecubital fossa.

The current recommendations for patients not requiring acute resuscitation are to minimize scene time and to establish IV access en route. Medical directors should know the diagnostic capabilities of area hospitals and encourage EMS units to establish IV access to meet these needs. Assuming that establishing an IV does not increase the EMS transport time, placing a line that meets therapeutic and diagnostic requirements may save critical time by eliminating the need to establish an IV as a first priority when the patient arrives at the hospital.<sup>10,11</sup>

### IV Fluid Administration

Once vascular access has been established, there is a tendency for EMS providers to administer intravenous fluids. However, it remains unclear what type of fluid to administer and how much to give. In theory, hemodilution will decrease viscosity, improve cerebral blood flow, and subsequently decrease infarct size. A Cochrane review on hemodilution for acute stroke using plasma volume expanders concluded that this therapy has not been proven to improve survival or functional outcome.<sup>40</sup> The administration of hypertonic saline has also been recommended to decrease ICP in the setting of acute stroke.<sup>41</sup> However, correcting ICP in the prehospital setting where it cannot be measured or monitored is potentially dangerous. In an animal study using hypertonic saline acutely for stroke without regard to monitoring ICP, hypertonic saline was shown to worsen the infarct size of cortical infarcts.<sup>42</sup> Glucose-containing solutions must be avoided because hyperglycemia has been shown to be detrimental in the acute setting.<sup>43,44</sup>

IV fluids should be used cautiously in stroke patients with other underlying medical conditions such as heart failure or renal failure in which volume overload could be detrimental. Conversely, patients who are dehydrated or poorly perfusing, should receive boluses of balanced salt solutions to improve circulation and potentially cerebral blood flow.<sup>45,46</sup> No benefit from routine hemodilution has yet been demonstrated for use in the acute setting. In patients who are hemodynamically stable, the current recommendation is to saline lock the line or run a balanced salt solution at a minimal rate to keep the line open (TKO).

### Electrocardiographic (ECG) Monitoring

Stroke patients are at risk for adverse cardiac outcomes as mediated through an increase in sympathetic tone and the release of catecholamines causing a proarrhythmic state.<sup>47–50</sup> The increase in tone can also cause

heart strain and myocardial infarction.<sup>51</sup> Potential ECG changes include QT prolongation, T-wave flattening or inversion, ST segment alteration, and supraventricular dysrhythmias.<sup>52,53</sup> Moreover, stroke itself can be caused by the release of blood clots associated with underlying atrial fibrillation or prior myocardial infarction. Given the wide range of cardiac risk factors and complications, continuous three-lead ECG monitoring, when available, is recommended for all cases.

### Blood Glucose Monitoring

In the setting of acute stroke symptoms, capillary blood glucose (CBG) measurement should be obtained as soon as possible. Early hypoglycemic patients can present with focal neurological findings that mimic a stroke.<sup>54</sup> In addition, severe and prolonged hypoglycemia can lead to brain injury such that prompt identification and correction of hypoglycemia is imperative.

The identification of hyperglycemic patients is also important. Hyperglycemia is recognized as an independent risk factor for increased morbidity and mortality following stroke.<sup>43,44,55</sup> Hyperglycemia worsens cerebral edema, enhances hemorrhagic transformation of the stroke, and exacerbates the postischemic injury.<sup>56,57</sup> The underlying mechanisms include increased anaerobic glycolysis leading to tissue acidosis as well as increased permeability of the blood brain barrier. Recent studies have identified the importance of starting early insulin therapy to achieve euglycemia.<sup>58,59</sup> Ongoing prospective trials to evaluate early glucose regulation will hopefully show the ideal interventions to improve long-term outcomes.<sup>60,61</sup> In the future, early management of hyperglycemia may be warranted in the prehospital setting. However, at present, no data exist to support this treatment.

In summary, it is important to check a CBG early to identify and treat hypoglycemic patients as well as identify hyperglycemic patients so that early in-hospital intervention can be started to establish euglycemia.

### Aspirin

The goal of early intervention in acute ischemic stroke is to restore blood flow to brain tissue by physically disrupting the clot and preventing further clot formation. Platelets are believed to play an important role in the pathogenesis of acute ischemic stroke and the antiplatelet drug aspirin has been demonstrated to have beneficial effects in the treatment of acute stroke.<sup>62,63</sup> The International Stroke Trial (IST) and the Chinese Acute Stroke Trial (CAST) evaluated the effects of early aspirin therapy (within 48 hours) on acute stroke and showed a reduction in the immediate risk of further stroke or death in the hospital setting and in the overall risk of death or dependency.<sup>64,65</sup>

In theory, giving aspirin to a person with a hemorrhagic stroke could worsen the bleeding. However, a subgroup analysis of the IST and CAST studies showed a net benefit with no unusual risk of hemorrhagic stroke in the use of early aspirin therapy.<sup>66</sup> Other studies have also failed to show an increased risk in the development or worsening of hemorrhagic stroke with the use of aspirin.<sup>67-69</sup>

There is no literature that has examined the benefits and risks of aspirin therapy for suspected stroke in the prehospital environment. Because the available literature does not show an increased risk of hemorrhage, aspirin could theoretically be given to patients with suspected stroke in the prehospital environment. However, as the literature demonstrates a benefit to aspirin therapy when given in the first 48 hours after onset of symptoms and there is a theoretical risk of hemorrhage, it is acceptable to delay aspirin therapy until after the patient has arrived at the emergency department. Further research is needed to delineate the benefits and risks of aspirin administration for suspected stroke patients in the prehospital environment.

### Blood Pressure Management

Blood pressure management in acute stroke has been a controversial topic.<sup>70</sup> In theory, a reduction in blood pressure should prevent additional strokes, reduce further vascular damage, decrease cerebral edema, and lessen the chance for hemorrhagic transformation of an ischemic area.<sup>71</sup> However, reducing blood pressure could also reduce cerebral perfusion and lead to enlargement of the area at risk for ischemic injury. Cerebral autoregulation is often disrupted in the setting of ischemia, and cerebral perfusion depends almost entirely on systemic arterial blood pressure. In studies that focused on the first 24 hours after an acute ischemic stroke, it has been noted that although initial hypertension is common, blood pressure often declines without intervention in the first 90 minutes.<sup>72,73</sup> Other studies have found that the initial hypertension associated with an acute ischemic stroke was protective and that interventions to lower it in the first 24 hours worsened outcome.<sup>74-76</sup>

For ischemic stroke, a range of systolic blood pressure (SBP) from 140 to 180 mmHg appears to be optimal and reducing SBP below 140 mmHg or by more than 20 mmHg is detrimental.<sup>76</sup> In fact, evidence is emerging for the use of vasopressors to increase SBP in the management of acute ischemic stroke.<sup>77,78</sup> Current recommendations for blood pressure management in ischemic stroke are to avoid anti-hypertensives in the acute setting unless SBP is >220 mmHg or if medically necessary for treating accompanying conditions such as acute myocardial infarction, decompensated heart failure, aortic dissection, acute renal failure, or hypertensive encephalopathy.<sup>79</sup> In hemorrhagic stroke,

the goal of blood pressure management is to maintain mean arterial blood pressure <130 mmHg and CPP >70 mmHg.<sup>80</sup>

Because of the importance of not overaggressively treating hypertension in acute stroke, blood pressure management in acute stroke should be done in a controlled manner with continuous assessment and close titration of medications used. Because it is very difficult to closely monitor blood pressures and titrate medications in the prehospital environment, current recommendations for the management of blood pressure in the prehospital environment for potential stroke patients are to not intervene and to let the body autoregulate.

### Level of Prehospital Care

The availability of advanced life support (ALS) level prehospital care varies from community to community. In communities where ALS care is not immediately available, basic life support (BLS) services can provide prompt and coordinated care of patients with suspected acute stroke, and transport should not be delayed when ALS care is not immediately available. Unless resuscitation is required, the BLS skills of early recognition of patients with suspected acute stroke, prompt transport, and coordination of care with the receiving facility are of more importance than the ALS skills listed above.

### Stroke Centers

As recently as 2000, Alberts et al. published recommendations from the BAC for the establishment of primary stroke centers.<sup>81</sup> These recommendations have since been adopted by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) for the accreditation of primary stroke centers.<sup>82</sup> The recommendations from the BAC focus on two main objectives: patient care areas and support services.

Since the publication of the original recommendations by the BAC, this organization, composed of a multidisciplinary group representing a variety of professional organizations and medical specialties, has subsequently published further recommendations for the development of comprehensive stroke centers.<sup>12</sup> It is the belief of the BAC that there should be two levels of stroke centers: (1) primary centers that are able to provide care for most acute stroke patients and (2) comprehensive stroke centers that act as a referral center for complex cases as well as provide a base for stroke education. In addition to these recommendations, the ASA has also published recommendations for the establishment of stroke systems.<sup>13</sup>

Both the BAC and the ASA recommendations include sections on EMS and the management of stroke patients. These recommendations highlight the importance of early identification and notification to receiving

hospitals of potential stroke patients, appropriate treatment of these patients, and transport and/or transfer to area stroke centers. Recommendations from the BAC stress the importance of continuing education programs on stroke for EMS personnel and the integration of the EMS system with the greater medical community in the development of stroke systems. The recommendations from the ASA focus on the appropriate identification of stroke patients, dispatch of appropriate level of service to these patients, and timely transport to stroke centers.<sup>13</sup>

To this date, there have been no studies published that have compared outcomes in patients who are primarily transported to a stroke center to patients primarily transported to a non-stroke center. However, there have been a number of studies published that have demonstrated improved outcomes when patients are either admitted to a stroke unit or receive specialized stroke care.<sup>83-88</sup> There are many possible reasons for improved outcomes when a patient is admitted to a stroke center.

In a prospective study of patients admitted to nine VA hospitals with acute ischemic stroke, Goldstein et al. demonstrated that patients cared for by neurologists have improved outcomes.<sup>89</sup> Mitchell et al. published similar findings in their study in which stroke patients treated by a neurologist had a 22% less mortality rate than similar patients treated by an internist.<sup>90</sup> A few of the possible explanations for improved outcomes when stroke patients are managed by a neurologist might be: focused diagnostics, appropriate treatment, prevention of complications, and rehabilitation.

On the basis of the available literature demonstrating improved outcomes when stroke patients receive specific treatment plans, JCAHO has published a list of 10 measures that should be considered in the certification of stroke centers.<sup>91,92</sup> While many of these measures can be accomplished at a typical community hospital, the coordination of all of these measures by a neurologist at an accredited stroke center has the potential to lead to improved outcomes in the care of stroke patients.

### IMPLICATIONS FOR EMS SYSTEMS

Emergency medical services systems are a vital component to the management of stroke patients. There continue to be emerging treatment modalities for stroke patients that are applicable to the out-of-hospital environment. Therefore, EMS medical directors should develop protocols that address a multitude of issues related to the care of stroke patients. These protocols may include appropriate identification and treatment of stroke patients as well as the integration of the EMS system into regional stroke systems.

For the identification of potential stroke patients, EMS medical directors should include training in stroke screening as a part of the formal curriculum within the EMS system. EMS providers working in emergency

dispatch centers as well as in the field should use a standardized method to identify and assess patients who may be having a stroke. Standardized screening is an important tool in early identification of potential stroke patients.

For the treatment of stroke patients, protocols should address position of patient during transport, use of oxygen therapy and airway management, placement of intravenous lines and administration of intravenous fluids, electrocardiographic monitoring, blood glucose monitoring and correction of hypoglycemia, administration of aspirin, and monitoring of blood pressure derangements. These protocols should be continuously reviewed to reflect current evidence-based treatment practices. EMS providers should also have regular continuing education in the evaluation and treatment of potential stroke patients.

Regarding stroke centers, there may be times when primary transportation to a stroke center is not feasible within an EMS system. There may be some EMS systems that will not have a stroke center in the geographic region. Some EMS systems may be in areas where primary transportation will require excessively long transports taking an EMS unit out of its primary coverage area. There may also be times when primary transportation to a stroke center may be contraindicated such as if the primary hospital is not the closest hospital and the patient is in need of emergent treatment for situations such as a compromised airway. However, in these situations when primary transportation to a stroke center is not feasible, secondary transfer of these patients to a hospital with specialized stroke services may be necessary.

Regarding the development of stroke systems of care, EMS medical directors and administrators should be active participants, if not leaders, in the development of regional stroke systems. It is important to note that there is controversy in the concept of developing stroke systems of care. There are no data that demonstrate improved outcomes when patients are primarily transported to stroke centers. However, there are data that show improved outcomes when patients are ultimately cared for at a hospital with the capacity to deliver specialized stroke care, even if this means secondary transfer from the facility where the initial therapy, including the decision to administer or not administer thrombolytics, is made. Therefore, EMS systems and medical directors should take a leadership role in developing local and regional strategies for the transportation of patients with acute stroke symptoms. These strategies should include the identification of (1) centers that are capable of providing acute stroke treatment (e.g., thrombolysis) and the criteria for identifying the patients who should be transported from the scene to these centers and (2) centers that have the capacity to deliver postacute stroke care, and EMS systems should anticipate and be able to accommodate potential sec-

ondary transfers of patients if they are initially taken to a center that doesn't offer these services.

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