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Prehospital Stroke Care Part 1: Emergency Medical Services and the Stroke Systems of Care

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Abstract

Acute stroke care begins before hospital arrival, and several prehospital factors are critical in influencing overall patient care and poststroke outcomes. This topical review provides an overview of the state of the science on prehospital components of stroke systems of care and how emergency medical services systems may interact in the system to support acute stroke care. Topics include layperson recognition of stroke, prehospital transport strategies, networked stroke care, systems for data integration and real-time feedback, and inequities that exist within and among systems.

Keywords

delivery of healthcare; emergency medical services; stroke; stroke center

Care for the acute stroke patient begins in the prehospital setting. Recognition of stroke symptoms, activation of emergency medical services (EMS), EMS practitioner stroke identification, and subsequent decision-making by EMS are critical. Well-functioning prehospital stroke care is integral to the overall stroke system of care.

This article is the first in a 2-part topical review series on the current state of prehospital stroke care. We provide an overview of the prehospital components of the stroke system of care primarily through the lens of the United States system, which is in many ways more fragmented than in places with centralized systems of planning. Nevertheless, the key principles are largely universal in the priority to design or improve systems of care with an aim of getting the right patient to the right location at the right time. The second, companion review includes more detailed discussions of on-scene prehospital evaluation and management of the patient with suspected stroke.

SYMPTOM RECOGNITION AND ACCESSING EMERGENCY MEDICAL CARE

Layperson Stroke Recognition

Recognition of stroke symptoms is a critical first step in the stroke chain of survival (Figure). Delays in recognition lead to delays in care seeking and contribute to reduced treatment efficacy[1] and ineligibility.[2–4] Early symptom recognition along with EMS activation contribute to reduced prehospital delays, and more timely, higher-quality care.[1,5–7]

However, the utilization of EMS by patients with stroke in the United States is suboptimal. Between 36% and 42% of stroke patients do not arrive by EMS,[6,8,9] and utilization is decreasing over time.[9] Use of EMS by stroke patients also varies by subpopulation, with lower use among persons of color, younger patients, and men.[6,8,9]

To address this, stroke awareness campaigns such as BE FAST and FAST have worked to improve symptom recognition while emphasizing rapid EMS response, including the multilingual equity-oriented approach of the Massachusetts Department of Public Health.[10] Other innovative strategies include school-based programs such as Hip-Hop Stroke.[11]

Yet there is evidence that the decision to make an emergency call (ie, 9-1-1 in the United States) is complex, and stroke knowledge alone is insufficient.[4,12,13] For example, fear induced by stroke symptoms may impact decision-making,[14] as can patients' perception of the seriousness of stroke symptoms.[6,9,15–17] Systemic factors experienced by marginalized populations such as poverty, racism, and adverse social determinants of health likely present additional barriers.[18] A study of Black populations indicated that distrust of the medical community and concern that EMS would not come to their stigmatized neighborhood impacted the decision.[14] Concern about the cost of ambulance transport is another barrier, which likely disproportionably impacts populations experiencing poverty.[14,16,19]

Many public awareness campaigns strive to capitalize on the key role of bystanders in symptom recognition and the decision to call 9-1-1.[16] Youth bystanders in particular have described motivation to call 9-1-1 due to perceived responsibility for the person's wellbeing.[14] Future work to address systemic barriers will be important to increase EMS utilization by patients with stroke, and studies leveraging qualitative or community-based participatory research methodologies may be particularly valuable.[4,14,20]

Accessing Emergency Medical Care During the 9-1-1 Call

The next key link in the stroke chain of survival occurs at the first point of contact between laypersons and medical personnel during an emergency call.[21] A call-taker/emergency medical dispatcher has a compressed time frame to gather critical logistical information (ie, address of the emergency), elucidate the type of emergency, and dispatch the appropriate responding unit.[22] The American Heart Association recommends this occur within 1 minute.[23,24]

Accurate emergency medical dispatcher recognition can have critical downstream effects for acute stroke patients. It has been associated with quicker on-scene times by responding paramedics, greater likelihood of transport to a stroke center, higher rate of and faster thrombolysis administration at the receiving emergency department.[6,25–29]

Yet the sensitivity of emergency medical dispatcher recognition is low, ranging from 41% to 83%, with most studies reporting a sensitivity of approximately 50%, particularly when emergency medical dispatchers do not have structured protocols to assist with stroke recognition.[29–40] The cause of this low sensitivity is likely multi-factorial, but an important potential causative factor is the language used by layperson callers to describe stroke. Laypersons often use inconsistent language when describing acute stroke, sometimes even using words that connote acute, time-sensitive conditions other than stroke.[40] The combination of distracting terms and the ultra-compressed time frame of the 9-1-1 call contribute to increased uncertainty for the emergency medical dispatcher and downstream delays in stroke recognition.

Future research and implementation of initiatives to support emergency medical dispatchers in accurate stroke recognition have been proposed as a target for stroke systems of care optimization and may be used as a model for identifying other time-sensitive conditions during the 9-1-1 call.[40–45] Although such interventions would be expected to improve all EMS systems, those with mobile stroke units may be particularly positively impacted by

high-fidelity stroke dispatch, enabling the treatment of more patients with true strokes and ultimately increasing mobile stroke units cost-effectiveness.[45–47]

STRUCTURAL COMPONENTS IN PREHOSPITAL STROKE SYSTEMS OF CARE

Stroke Center Certification

Stroke center certification is critical to standardizing the recognition of hospital capabilities within stroke systems of care. Third-party certification information, with uniform standards, may be incorporated into prehospital protocols to ensure appropriate, rapid transport for patients with suspected stroke. This ensures patients are treated at a hospital with the ability to provide indicated therapies such as thrombolysis, endovascular thrombectomy (EVT), clipping of intracranial aneurysms, or other acute interventions for hemorrhagic stroke. This also enables the design of strong stroke systems of care for a specific geographic region. Certification of stroke centers by independent organizations is an American Heart Association Level 1B recommendation.[1] Agencies providing stroke center certification include Joint Commission, Det Norske Veritas, Healthcare Facilities Accreditation Program, Center for Improvement in Healthcare Quality, and state-based certifiers.[48–50]

There are 4 established levels of certification: Acute Stroke Ready Hospital, Primary, Thrombectomy-Capable, and Comprehensive Stroke Centers.[48,49,51–53] Each has unique components to fulfill particular diagnostic and treatment needs within the system.[49,51–53] Acute Stroke Ready Hospitals are often located in rural settings and function primarily to assess and stabilize patients (including the administration of intravenous thrombolytics) prior to transfer to a higher level of care according to patient needs.[49,51,52]

There is some evidence suggesting that even among primary stroke centers, quality of care varies between sites and by certifying organization.[50] Further differences exist between certified stroke centers and nonstroke centers; hospitals certified as stroke centers tend to be located in higher income service areas, have higher profit margins, and are less likely to be located in rural areas, demonstrating the impact of economic characteristics of patient populations on certification.[54,55] Finally, globally, stroke center certification is more established in high-income countries and regions compared with low- and middle-income countries.[56,57]

Integration of Prehospital and Hospital Data

Timely feedback is a vital part of continuously improving diagnostic skills and treatment decisions; yet this is uncommonly and inconsistently delivered to frontline EMS practitioners.[58] Lack of feedback may lead to miscalibration with EMS practitioners over- or under-estimating the accuracy of their decisions. Up to one-in-three strokes diagnosed in the emergency department were unrecognized prehospital.[59,60] Differences between prehospital and hospital diagnoses are understandably common but can lead to further diagnostic errors.[61] Prehospital recognition is a necessary first step before prenotification of the receiving emergency department. Error may lead to delays in door-to-imaging or

treatment times, and translate to worse patient outcomes.[25] Analyses suggest that few EMS encounters are fully concordant with guideline recommendations.[62]

Hospital-directed feedback increases prehospital compliance with guideline-concordant care, including documentation of a prehospital stroke assessment and last known well time.[63] Unfortunately, such processes are uncommon and tend to be resource intensive. Yet health information technology and automated linkage of EMS and hospital data may provide an opportunity for more large-scale improvement efforts related to stroke systems of care.[64] Although the practice is not yet a widespread standard, routine linkage of EMS data with hospital data is increasing. Several methods for prehospital and hospital data linkage exist, including health information exchanges, specialized registries, and system interface software from electronic patient care record vendors.[65–67] Currently, many data linkage efforts are performed retrospectively and are research-focused, rather than a source of real-time feedback for EMS practitioners. Establishing real-time, bidirectional data exchange could serve as a key strategy to provide EMS practitioners with the feedback they desire, improve patient care, and even help mitigate the effects of work-related burnout.[68,69] Local projects have demonstrated the feasibility and benefits of automated real-time bidirectional exchange, allowing front-line EMS practitioners direct access to outcome data.[70,71] This may also be of value for the emergency department and in-hospital care of the patient with stroke by ensuring timely access to key information collected by EMS.[72,73] Certified hospitals should lead in this work.

Yet data linkage alone will not generate action and improvement. Prehospital and hospital feedback systems should systematically combine linked data with input from clinical and administrative leaders on both sides of the feedback loop to interpret findings and identify points for system-wide improvement.[64] This multi-dimensional approach for health information technology-supported feedback systems involving data linkage technology and a culture of information sharing supports the development and evolution of collaborative, integrated approaches to stroke systems of care.

PATIENT MOVEMENT WITHIN A STROKE SYSTEM OF CARE

Transport Destination

A critical goal in the configuration of stroke systems of care is in enabling rapid reperfusion therapies for eligible patients.[4,74] Since 2015, with overwhelming evidence of the benefit of EVT for large vessel occlusion stroke, the organization of EMS transport protocols has become more complex. Prehospital routing decisions must now consider whether to bypass closer facilities with thrombolysis capabilities for EVT-capable centers.[75]

Several observational studies and meta-analyses including EVT-treated patients suggested that direct transport to a thrombectomy-capable center was associated with better functional outcomes, likely due to reducing transfer-related delays in EVT.[76–78] To date, the only randomized clinical trial comparing transportation to a Thrombectomy-Capable Centers/Comprehensive Stroke Centers versus the closest local stroke center was the RACECAT trial (Transfer to the Closest Local Stroke Center vs Direct Transfer to Endovascular Stroke Center of Acute Stroke Patients With Suspected Large Vessel Occlusion in the

Catalan Territory), performed in Catalonia, Spain. Patients with a prehospital Rapid Arterial oCclusion Evaluation (RACE) scale of 5 or greater had no significant difference in 3-month neurological outcomes between the 2 transport paradigms.[79] However, external validity of this study may be limited, as the study region has a highly coordinated and effective stroke care network. Sixty percent of AIS patients received thrombolysis at the local center, and flow was very efficient. Times were extremely fast in both paradigms, even in transferred patients (median door-to-needle time 33 minutes, door-in door-out time 78 minutes, and a difference of only 56 minutes in total time from onset-to-EVT between the 2 groups).

High-quality randomized clinical trial data from other stroke systems with geographical and logistical differences are lacking.[80] In fact, observational data from other regions with directed transport protocols but different efficiencies than Catalonia are less clear, with some suggesting improved outcomes for direct-transport patients.[81–85] Mathematical modeling suggests that the preferred destination is more complex and may be dependent on system-specific factors, such as differences in transport time and when receiving emergency departments are less efficient.[86,87] It is likely that optimal prehospital routing decisions are highly dependent on particular characteristics of individual patients, EMS agencies, and receiving hospital efficiencies. Recent recommendations have acknowledged such nuance in routing recommendations.[88]

Lastly, with the notable exception of RACECAT, prior studies have largely included only patients with confirmed large vessel occlusion who were EVT-eligible on arrival at the EVT-capable center. In the vast majority of prehospital systems (ie, those without mobile stroke units), accurately distinguishing true stroke from mimic is limited, let alone identifying large vessel occlusion. Ideally, screening tools would identify thrombectomy candidates and discriminate between patients who may benefit from transport to Comprehensive Stroke Centers despite longer times versus those who may experience a dilution of treatment benefit, lose the opportunity for thrombolysis (eg, patients without large vessel occlusion), or even potentially introduce harm (eg, certain hemorrhagic stroke patients). However, the positive predictive value of available prehospital stroke severity screening for large vessel occlusion is, at best, 50%.[89] Further, prehospital stroke severity screens have limited ability to discriminate between types of severe stroke (ie, large vessel occlusion or hemorrhagic stroke); more data are required to inform optimal screening and transport. Ultimately, prehospital evaluation tools that allow for more precise, even personalized, decision-making may be needed.[90] Additionally, technology-based solutions incorporating artificial intelligence or complex algorithms may improve the reliability of appropriate prehospital transport.[80]

Network Approach to Prehospital Stroke Systems of Care

The structural configuration of the healthcare system underlies the nature and configuration of stroke systems of care.[4,91] This includes how patients are transported to emergency departments and between hospitals, where hospitals and resources are located, how health systems interact with their surrounding communities, and the existence of policies that reinforce or ameliorate legacies of segregation and inequitable access.[92] The stroke system of care is thus interconnected and interdependent, and requires tools that enable

sophisticated analyses of systems with many interacting components.[93] Approaches from network science provide a valuable set of tools for studying and improving the prehospital stroke system.[94] Such analyses are useful for describing structural relationships in organizational networks[95] and may uncover prehospital transport patterns and network structure that underlies connections between EMS, prehospital systems, emergency departments, and hospitals to which patients are transported. For example, network methods have been used to study the influence of hospital characteristics on interhospital transfer destinations when patients with stroke are transferred between hospitals, demonstrating the influence of hospital affiliation on destination choice, even to a greater extent than hospital stroke center certification or reputation.[96] Similar analyses in the prehospital setting may inform prehospital transport policy. For example, in the United States, some EMS systems and many mobile stroke units are operated by hospital systems, which raises the potential concern for preferential transport of patients to destinations within that hospital system. Network approaches may be valuable to study these patterns and examine the extent to which preferential transport benefits patients versus hospital systems.

STROKE IN LIMITED RESOURCED SETTING

Prehospital systems of care for stroke in resource-limited settings, such as in rural communities, face additional sets of challenges in providing timely, high-quality care. In general, access to acute stroke care has increased substantially over time, though over one-third of the US population remains over 60 minutes from a Thrombectomy-Capable or Comprehensive Stroke Centers by ground transport.[1] Rural patients are also less likely to call 9-1-1 and be transported by EMS.[6] Even with prompt activation, EMS response times for rural patients often exceed the <8-minute goal set by the American Heart Association.[1,97,98] Transport times may also be extended, and median transport times are significantly longer in frontier areas.[97]

The feasibility of EMS transport to a stroke center also varies in rural areas, and the existence of direct-transport protocols is variable.[99,100] Current recommendations are that rural EMS consider the transport of patients with suspected stroke, particularly those with suspected large vessel occlusion, to the closest facility capable of administering thrombolysis if the transport time to a Thrombectomy-Capable or Comprehensive Stroke Centers would exceed a reasonable threshold (eg, 60 minutes).[88] In rural and limited-resourced areas, transport times by ground may greatly exceed that threshold, requiring eventual inter-facility transfer after initial local assessment and treatment. Recently, there has been a paradigm shift in bringing care to the patient rather than the patient to care. For example, some rural areas, especially outside the United States, have established mobile stroke units to increase access to thrombolysis,[101–103] transported endovascular specialists to outlying hospitals,[104,105] or developed methods for telestroke consultations during EMS transport.[106]

Aeromedical transport is another alternative in rural settings to provide rapid transport to higher-level care from the scene. About 90% of EMS personnel reported access to at least 1 helicopter EMS service and 86% had the authority to request a helicopter EMS scene response,[107] though stroke is an infrequent use.[108] Advantages of air transport for

stroke are unclear, and the cost effectiveness of using helicopter EMS resources depends on travel distance and time since last seen well.[109,110] Overtriage and transport of stroke mimics is also common,[111,112] leading to “low value” helicopter EMS activations. When accounting for response time, a helicopter may not save time if ground transport can commence quickly.[113,114] Finally, clinical outcomes may not differ substantially among patients transported by air compared with ground.[110] The best use of helicopter EMS resources for acute stroke in resource-limited settings remains unclear.

Workforce capabilities and call volumes may also affect acute stroke care in resource-limited settings. Rural areas more commonly rely on volunteer EMS personnel and are less likely to have advanced life support care available.[115,116] The ongoing challenges with EMS workforce shortages and stability in the United States are even more pronounced in rural areas.[117–119] Thus, particular consideration is needed regarding constraints of the local EMS system and workforce, and its implications for staffing of ambulances and availability to respond to community needs.

INEQUITIES IN PREHOSPITAL STROKE CARE

In 2022, the NINDS Brain Attack Coalition convened to explore inequities and potential solutions across the stroke care continuum.[106] Priority areas were developed through subject matter expertise and a critical assessment of the literature. Experts across the country were invited to identify solutions along 4 domains: (1) geography, (2) policies and regulations, (3) economics and healthcare resources, and (4) demographics (race, ethnicity, and gender). The following is a brief overview of ideas generated from the discussions with a focus on the prehospital setting.

Geography

Geographic disparities in access to high-quality prehospital stroke care are linked to differences in access to stroke centers, which may adversely affect patient outcomes.[120] Rural–urban differences in prehospital stroke care have been linked to the limited frequency at which strokes are seen by rural EMS providers, long drive times, and inconsistent wireless connectivity.[51,74,108,111] Disparities in stroke mortality are heightened in rural areas, US territories, and across Native peoples’ reservations, as access to nearby hospitals with stroke expertise is limited.[51,74,109,110] Successful and efficient prehospital stroke management may benefit from more research on the impact of regionalized stroke center networks, standardization of screening tools, routing protocols, and the use of telestroke to facilitate ambulance-based assessments.[88] Incorporating these factors in a geographically mindful way may facilitate collaboration and decrease geographic disparities.

Policies and Regulations

The regulation of EMS in the United States occurs largely at state and local levels. Federal entities, such as the National Highway and Transportation Safety Administration, the Federal Interagency Committee on EMS, and the National EMS Advisory Council, also provide guidance and coordination among regional EMS entities.[23,88] As a result of this tiered system of regulation, coordination of policies is variable, even within states.

Fragmentation of policies may result in differential access to high-quality EMS care for patients.[1,51] Thus, a better understanding of how standardization of polices and regulations that support reducing disparities in prehospital stroke care is warranted. Areas to explore may include policies related to EMS reimbursement based on the complexity of assessment and destination decision-making for strokes; culturally-informed EMS stroke education and training; and systematic EMS data collection linked to patient outcomes that support the creation of meaningful metrics to promote equity in stroke care quality improvement.[1,51]

Economics and Healthcare Resources

Prehospital care systems are often interdependent with hospital systems, and both may reflect the underlying economic basis associated with the communities that they serve.[65,66] Variability in the economic base of communities may also be associated with disparities in stroke care and outcomes.[112] Low-resourced and historically marginalized communities may have different barriers to activating EMS and reduced access to trained healthcare professionals specialized in stroke care.[51] Improved understanding of underlying economic drivers of healthcare resource allocation, EMS reimbursement, and work-force solutions that target professionals that commit to treating patients in underserved areas may impact disparities across the continuum.

Demographics

Sociodemographic differences in utilization of EMS transport among hospitalized stroke patients have been consistently documented.[8] Multiple community and prehospital-related factors may contribute to the downstream demographic disparities in stroke treatment rates related to sex/gender, race, ethnicity, socioeconomic status, and insurance status.[51,113–115] These sociodemographic disparities contribute to inequitable access to emergency care, which in turn results in disparities in access to efficient stroke diagnosis and treatment for members of disenfranchised communities, even in geographic areas with adequate stroke resources. Priority areas that may reduce sociodemographic disparities in the prehospital stroke setting include (1) the development of a high-quality, systematic, and comprehensive national data set that may be used at the community level to provide information for targeted interventions and (2) an expansion of programs to enhance public education about stroke identification and acute management, especially for populations and/or regions where disparities exist.

SUMMARY AND CONCLUSIONS

Optimal prehospital care of stroke patients is imperative for downstream high-quality care in the emergency department and in-hospital, ultimately resulting in improved patient outcomes. Ongoing investment is needed in processes to improve symptom recognition and communication, develop additional evidence to inform routing destination decisions, processes for data integration for enabling feedback as a component of continual quality improvement and strategies for ensuring equitable access to high-quality acute stroke care for all patients.

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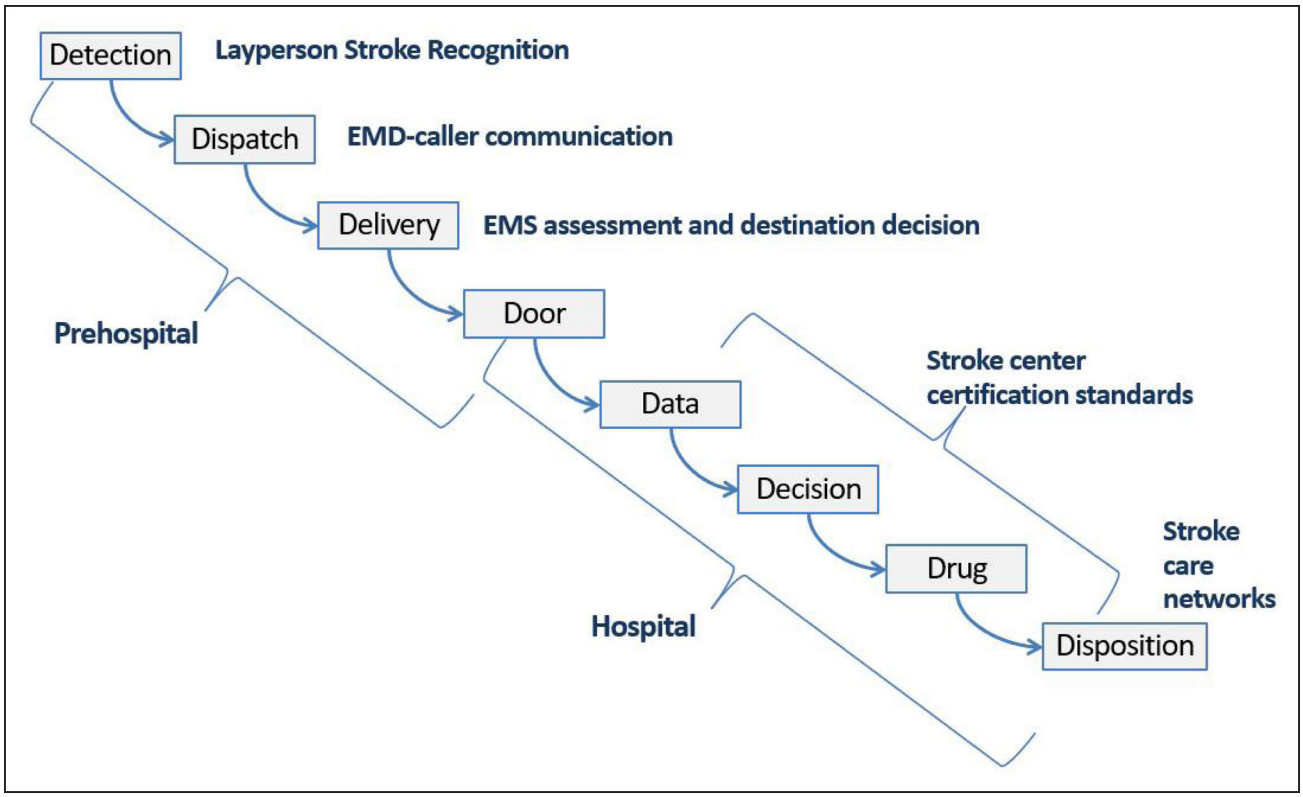

Figure. Stroke chain of survival within a systems of care framework.
EMD indicates emergency medical dispatcher; and EMS, emergency medical services.