ASA Policy Statement

Recommendations for the Establishment of Stroke Systems of Care: A 2019 Update

A Policy Statement From the American Stroke Association

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Abstract—In 2005, the American Stroke Association published recommendations for the establishment of stroke systems of care and in 2013 expanded on them with a statement on interactions within stroke systems of care. The aim of this policy statement is to provide a comprehensive review of the scientific evidence evaluating stroke systems of care to date and to update the American Stroke Association recommendations on the basis of improvements in stroke systems of care. Over the past decade, stroke systems of care have seen vast improvements in endovascular therapy, neurocritical care, and stroke center certification, in addition to the advent of innovations, such as telestroke and mobile stroke units, in the context of significant changes in the organization of healthcare policy in the United States. This statement provides an update to prior publications to help guide policymakers and public healthcare agencies in continually updating their stroke systems of care in light of these changes. This statement and its recommendations span primordial and primary prevention, acute stroke recognition and activation of emergency medical services, triage to appropriate facilities, designation of and treatment at stroke centers, secondary prevention at hospital discharge, and rehabilitation and recovery. (***Stroke*. 2019;50:e187-e210. DOI: 10.1161/STR.0000000000000173.**)

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To translate advances in scientific knowledge and innovations in clinical care into improvements in patient outcomes, systems must be in place to facilitate optimal healthcare delivery. In acute stroke, scientific knowledge and clinical care have improved in the past 2 decades. In light of these improvements, the American Stroke Association (ASA) first issued policy recommendations for the development of stroke systems of care in 2005.[1] A subsequent statement in 2013 issued recommendations on the interactions within stroke systems of care.[2] Several other American Heart Association (AHA) and ASA publications continue to provide guidance on improving stroke care.[3–8] The past 10 years have witnessed additional gains in knowledge and methods to improve stroke outcomes (eg, extension of intravenous alteplase to 3–4.5 hours, hemicraniectomy, endovascular thrombectomy, telestroke, stroke center certification, mobile stroke units [MSUs], neurocritical care) in the context of significant changes in the organization of healthcare policy in the United States. This statement provides an update to prior publications to help guide policymakers and public healthcare agencies in continually updating their stroke systems of care in light of these changes. This statement and its recommendations span primordial and primary prevention, acute stroke recognition and activation

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of emergency medical services (EMS), triage to appropriate facilities, designation of and treatment at stroke centers, secondary prevention at hospital discharge, and rehabilitation and recovery.

The public health implications of an optimized stroke system in the United States and worldwide are profound. A system of care that reduces stroke-related deaths by just 2% to 3% annually would translate into ≈20 000 fewer deaths in the United States alone and ≈400 000 fewer deaths worldwide. Reducing poststroke disability would also improve quality of life, reduce costs, and reduce the burden on patients, their families, third-party payers, and governments.

The key components of a modern stroke system of care are outlined here. Operationalizing these elements will vary in different parts of the United States (and the world). However, the general approach and principles should be useful to many healthcare professionals and others involved in such a system.

Burden of Stroke

Someone in the United States has a stroke every 40 seconds, and someone dies of a stroke every 4 minutes.[9] About 7.2 million Americans ≥20 years of age have had a stroke.[9] Approximately 800 000 people in the United States have a new or recurrent stroke each year.[9] Data from 30 239 participants in the REGARDS cohort study (Reasons for Geographic and Racial Differences in Stroke) showed that 22.5% of the population >45 years of age reported stroke symptoms, transient ischemic attack (TIA), or a recent or distant stroke.[10] Blacks are more likely to report stroke symptoms than whites.[11] Those with lower income and lower education are more likely to report stroke symptoms.[9] It is estimated that an additional 3.4 million US adults ≥18 years of age will have had a stroke by 2030, with the highest increase (29%) projected to be in Hispanic men.[13] The burden of stroke is borne by both survivors and families/caregivers. Poor quality of life in caregivers is associated with increased rehospitalization and costs of care for the stroke survivor.[14] In 2015, the estimated total cost for stroke in the United States was $66.3 billion, and this is projected to increase to $143 billion by 2035.[15]

Problem Statement

Optimized stroke systems of care that span healthcare delivery from primordial prevention to rehabilitation and recovery can improve communication across patient care domains; identify relevant performance measures and key patient- and system-related outcomes; and provide patients, caregivers, and providers with tools needed for prevention, treatment, and recovery. Adoption of a standardized approach to stroke systems of care in Canada has led to a 15% relative reduction in 30-day in-hospital mortality in acute stroke.[16] Implementation of Get With The Guidelines–Stroke at US hospitals has also been associated with an 8% reduction in mortality at 1 year and improved functional outcome at hospital discharge.[17] Thus, ineffective systems of care may themselves be a factor associated with worse stroke outcomes and therefore are an important area of focus.

Role of the ASA: Purpose of Statement

The purpose of this statement is to refine and revise the ASA stroke systems of care policy statement and recommendations to reflect the important scientific and clinical advances that have occurred since the last version of this statement.

Key Components of Stroke Systems of Care

Key Stakeholders

Essential for developing a cohesive, aligned regional or state stroke system of care is identifying and engaging all potential stakeholders at the outset. Early incorporation of all stakeholders ensures that the concerns of various groups are considered and addressed before the program is too far along. Often, the absence of a critical stakeholder is recognized during the process, and the concerns of that stakeholder create significant obstacles to moving forward. Fortunately, developing regional stroke systems of care has predicates for these efforts. Similar systems of care have been created to provide optimal regional care for patients with acute myocardial infarction and trauma.[18] Drawing from these local programs and incorporating successful components into the stroke system of care can accelerate optimal stroke care models.

Planners of a stroke system of care should consider the term *stakeholders* in a very broad sense. Stakeholders should draw from key constituents, broadly healthcare providers, patients, caregivers, hospitals, home health companies, regulatory agencies, and payers.[19] Healthcare providers should represent the major types of physicians, nurses, and allied health providers who are engaged in the care of stroke patients.[20] For acute care systems, important physician specialty stakeholders commonly include emergency physicians, vascular and general neurologists, neurosurgeons, neuroradiologists, neurointensivists, and hospitalists. Important nursing stakeholders include emergency care and neuroscience nurses, speech/language pathologists, and stroke center coordinators. Important allied health stakeholders include paramedics and emergency medical technicians. For prevention systems, important additional physician specialty stakeholders include internists, geriatricians, and cardiologists; additional stakeholders include behavioral psychologists, nutritionists, and urban and regional planners. For rehabilitation and recovery systems, important additional physician specialty stakeholders include physiatrists and neurorehabilitation neurologists. Additional stakeholders include physical, occupational, and speech and language therapists; rehabilitation nurses; social workers; and home health agencies. Hospital representation from across the range of geographic areas within the region and across a broad scope of hospital types should be involved. State and regional health policymakers, including the US Department of Health and Human Services; US Department of Transportation, National Highway Traffic Safety Administration's Office of Emergency Medical Services; Federal Office of Rural Health Policy, Health Resources and Services Administration, US Department of Health and Human Services; and key legislative champions if available, are essential and often lead the process. Rehabilitation personnel, including physiatrists and physical and occupational therapists in collaboration with nurse care coordinators, social

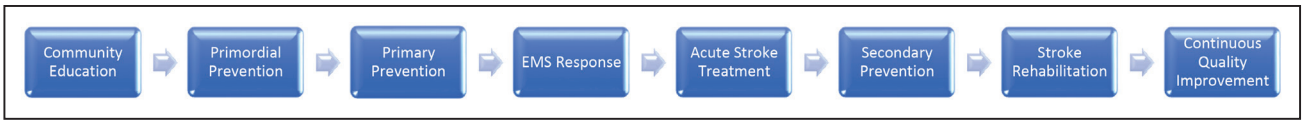

Figure 1. The 8 domains of a stroke system of care. EMS indicates emergency medical services.

workers, and home health agencies, among others, are essential to recovery throughout the continuum. Because there are multifaceted levels of rehabilitation, it is critical that rehabilitation team leaders representing various areas of rehabilitation are included in the system of care development. Patient engagement through either committed individuals or patient advocacy groups ensures that decisions are patient centered. Lastly, hospital administrators, hospital associations, and payers in the region help shape the economic discussions and should contribute to the program. The challenge for organizers is to ensure appropriate representation yet not create a group that becomes too large, unwieldy, and unfocused. Often, it is most efficient to first establish an acute stroke system of care and then expand it to other stroke domains such as access to prevention, public education, and rehabilitation and recovery.

Components of a Stroke System of Care

Primordial/Primary Prevention

Multiple frameworks have been proposed to outline system-based actions taken to improve public health. A visual continuum of the 8 domains of a stroke system of care (as shown in Figure 1) demonstrates how each part affects tertiary disease prevention.[21] As an algorithm for the health promotion to disease prevention continuum, opportunities to achieve better health consider not only environmental, cultural, economic, and social influences in a population but also the resources allocated for the provision of public health initiatives. Both cardiovascular disease and stroke are leading causes of death and adult disability.[22,23] Thus, they have been the focus of a multitude of national and worldwide primordial and primary prevention causes to reduce the downstream burden of these diseases and the associated lifelong sequelae that affect both patients and families. Stroke systems of care have championed these efforts.

Primordial prevention represents a paradigm shift for integrating resources and policies that target broader at-risk patient populations. Primordial prevention encompasses actions taken to inhibit health risk factors and subsequently to prevent chronic disease in selected or whole communities. Programs that address social conditions (inadequate housing and lack of access to primary care), health behaviors (sedentary behavior, smoking and exposure to smoking), or diet patterns (foods with high fat/high salt content) address the risk for developing hypertension, heart disease, obesity, and stroke from fetal development to older age.[24] Primordial stroke prevention has enjoyed the efforts championed by stakeholders that have addressed strategies to reduce hypertension, diabetes mellitus, heart disease, and obesity, all identified as major risk factors for stroke.

Primary prevention refers to the actions addressing established risk factors associated with specific diseases. It includes both population-directed strategies and targeting of individuals with specific risks. Healthcare providers and local and regional programs address commonly known risk factors for chronic disease by either prescribing specific protection measures (prescribing antihypertensives for high blood pressure, prescribing aspirin for patients with stroke risk factors) or promoting healthy behaviors (supporting smoking cessation programs).[25–27]

Within the past 2 decades, a multitude of local, state, and national campaigns were launched to increase stroke awareness and to reduce stroke burden in communities across the United States. A look back at the success of the US Department of Health and Human Services 2010 Healthy People initiatives shows a reduction in stroke deaths by 23% (from 62 to 42 deaths per 100 000).[28] The follow-up Healthy People 2020 initiative aims to improve cardiovascular health of Americans by 20% and to reduce cardiovascular events by 20%.[29] The AHA recently prioritized primordial and primary prevention policies for heart disease and stroke by promoting access to healthier (reduced sodium) and less costly foods, improved food labeling, and physical exercise programs in schools and the workplace.[24] The US Department of Health and Human Services launched its Million Hearts Program to prevent 1 million heart attacks and strokes through science, quality, and safety programs; partnerships with private sector groups; and public policy and multimedia marketing efforts.[30] The AHA published a policy statement to increase awareness of the social determinants of risk factors and outcomes for cardiovascular disease, offering recommendations for research on effective interventions.[31]

Despite these efforts, gaps remain in the application of many public health practice recommendations to the routine care provided by primary healthcare providers and to the health habits of many individuals in developed and developing countries.

Clinicians, policymakers, and numerous courageous stroke survivors play a key role in supporting the "pyramid base" by promoting programs that prevent the emergence of risk factors for developing disease.[32] The 2005 AHA/ASA recommendations for the stroke systems of care task force listed primordial/primary stroke prevention as 1 of 7 required elements of an organized stroke system.[1] The 2013 AHA/ASA policy statement on interactions with stroke systems of care included the recommendation that health authorities, including government agencies, support the certification of stroke centers as a valid means to improving patient care and stroke outcomes.[2] National campaigns to end stroke (eg, "Target: Stroke" and "Together to End Stroke") and to consider a lifestyle choice (eg, "Life's Simple 7") have become common slogans at health fairs.[33–35] Nationally certified acute stroke-ready hospitals (ASRHs), primary stroke centers (PSCs), thrombectomy-capable stroke centers (TSCs), and comprehensive stroke centers (CSCs) are required to engage in community programs that increase stroke awareness, stroke risk factor modification, and lifestyle changes.

A mature local, regional, or national stroke system of care must incorporate primordial/primary prevention. It is

important that disparities in access to prevention care be identified and targeted for corrective action. For example, adult blacks are known to be at twice the risk for stroke given that more than half have ≥2 vascular risk factors.[11,36] Therefore, more preventive efforts and resources are required for these populations. Data on the prevalence of obesity, diabetes mellitus, and cardiovascular disease reveal that Hispanics and blacks are twice as likely to have any one of these comorbidities that can lead to stroke.[37] Several chronic disease care models are currently being tested as a potential solution for improving patient outcomes with cerebrovascular disease.[37]

Recommendations

1. A stroke system should develop support mechanisms to assist communities and providers in initiating prevention regimens applicable to broader populations. (Unchanged from 2005)

A stroke system should emphasize support tools and measures designed to enhance provider awareness of stroke prevention strategies and current evidence-based treatment recommendations. Providers should be encouraged to and assisted in initiating primordial and primary prevention strategies and in putting in place referral plans that conform to recognized stroke treatment recommendations. Communities are encouraged to use all available resources, including public health departments, to ensure optimal stroke care, and public policy initiatives should support such efforts.

2. A stroke system should develop support mechanisms to assist communities as a whole, patients, and providers in long-term adherence to primordial and primary preventive treatment regimens. (New)

Comprehensive support mechanisms should incorporate multiple strategies that target both providers and patients, and these strategies should take into consideration cultural and geographic customs. Education and practice tools should be developed with health literacy targets appropriate to the linguistic needs and education levels of the targeted population. These frameworks should be designed to support providers in monitoring current stroke prevention recommendations. Useful support tools may include disease management programs and medication adherence interventions.

Community Education and Engagement

A necessary component of integrated stroke systems of care is a commitment to a forum for public awareness and education that spans primordial and primary stroke prevention topics, stroke symptom recognition and response algorithms, and secondary stroke prevention and rehabilitation and recovery strategies. Educational initiatives should target broad age groups, various socioeconomic stations, numerous racial/ethnic demographics, multigenerational families, coworkers across a variety of workplaces, and wide geographic locations. Prevention efforts must involve primary care physicians and advanced practice practitioners. Nontraditional sources of public education and preventive care, such as urgent care centers and emergency departments, should also be engaged because they may be the only points of medical contact for populations with poor access to primary care. Campaigns focusing not only on stroke symptom recognition but also on stroke preparedness, addressing health literacy and cultural tailoring to neurologically underserved communities, have demonstrated considerable promise.

Public awareness campaigns are a popular venue for raising awareness and understanding of various health-related topics. With the approval of alteplase as an acute treatment option for ischemic stroke in 1996 and with the establishment of PSC certification standards in 2003, many efforts on local, regional, and global fronts have occurred over the past decade to promote stroke awareness.[33,34,38,39] These efforts have triggered interest in tracking patient-related and system-related outcomes, cultural and behavioral attitudes toward recovery, and public support for further epidemiological and translational research.[40]

In the United States, ASA public educational and awareness campaigns to reduce the incidence of stroke have been extensive. In 2006, Power to End Stroke was created to reduce stroke and the risk of stroke. It was specifically designed to raise awareness in high-risk communities such as the black population.[39] "Stroke's No Joke" was a public service announcement campaign launched in 2009 to inform blacks about stroke warning signs and the urgency to seek care (by calling 9-1-1).[41] Using black stand-up comedians, this campaign addressed cultural competence, racial disease disparities, and social influences that shape relationships between individuals and the medical institutions.[41] In an analysis of the 2014 National Health Interview Survey, age-adjusted stroke awareness was 66%, and stroke awareness was lowest for Hispanics, blacks, and those residing in the western United States; the least recognized stroke symptom was sudden severe headache.[42] In 2013, the ASA, along with several industry sponsors, launched Together to End Stroke to increase awareness of stroke across the entire continuum of care, including prevention, acute treatment, and poststroke rehabilitation.[34] Built into this program was a hip-hop video competition to attract younger members of communities to join the campaign. The effectiveness of each individual campaign is unknown, but the disease-specific campaigns fit within the context of the larger US Department of Health and Human Services Healthy People 2010 and 2020.[28,29,33,34,38,39,41]

Community-based participatory research is a newer approach to enduring engagement of communities addressing factors limiting positive health behavior. For stroke, prior research has consistently found that although stroke knowledge was important, it was not enough to significantly improve health behavior.[43] Other factors limiting an individual's decision to access health care also likely influence behavior. Several innovative projects have focused on community education to address specific barriers within the stroke system of care. Focused on why patients do not receive timely acute stroke treatments, "Stroke Ready," a community-academic partnership in Flint, MI, has piloted interventions in the black community to improve stroke preparedness in order to decrease prehospital delay and to increase local stroke treatment rates.[44] Using community engagement and partnerships, Stroke Ready increased appropriate stroke responses, including stroke recognition and individuals' recognition of their own barriers that influence behavior (eg, willingness to call 9-1-1). The ASPIRE project (Acute Stroke Program of

Interventions Addressing Racial and Ethnic Disparities) in the District of Columbia is another project using a community-engaged approach to stroke preparedness such as decreased stroke presentation times and increased thrombolysis use, targeting underserved black communities.[45] To measure improvement in acute treatment rates, large-scale interventions, such as the TLL (Thomas Lewis Latané) Temple Foundation Stroke Project, which was a large community-based grant to improve stroke awareness and treatment in East Texas, or others, are needed to demonstrate the effectiveness of community stroke preparedness interventions.[46]

There is a recognized need for a new conceptual model for behavioral theoretical interventions for the prevention of stroke. Despite major advances in acute stroke treatment, there remains a mismatch between poor health outcomes for stroke and the high spending on services provided. Stroke is an obvious target for focused interventions because 10 of the stroke risk factors are associated with roughly 90% of the population-attributable risk of stroke around the world across race, ethnicity, sex, and age.[47] Current social and behavioral factors leading to risk factors for ischemic and hemorrhagic stroke have been studied, but our current interventions are insufficient to address and implement long-term change. Promising new paradigms based on social cognitive theory are emerging that are patient-centered principles and predictors that may inform and motivate people to adopt healthy lifestyles.[48] Once societal organizations and individuals jointly take on accountability for healthy behaviors, potential barriers to implementation and participation can be identified, and then new tools and technology that currently exist and pervade modern society can be brought to bear on this challenging problem.

First, the use of available technology for the passive surveillance and evaluation of patients' behaviors may be used to establish a baseline and to measure future change. Second, media and social network applications (eg, Facebook, Twitter, Instagram, Snapchat) are all available channels to engage individuals, to increase the visibility of healthy behaviors by role models, and to modify positive or negative reinforcement through posts and sharing. Third, behavioral economics (ie, the study of how individuals make successful and unsuccessful attempts to pick best options) and gamification to alter behavior (eg, use of pedometers or calorie devices to challenge individuals and groups toward positive healthy behavior) are novel strategies that should be considered in policy change. The availability of social cognitive theory and the emergence of pervasive digital tools offer tremendous opportunity for future medical behavioral interventions.[40]

These ongoing activities represent advances in the efforts of stroke systems to integrate existing and novel educational initiatives to improve public education focused on stroke symptoms, treatment options, and specifically how rapid care can significantly increase the percentage of patients eligible for acute reperfusion therapies. In the future, local, regional, and national stroke systems must expand such efforts to the entire continuum of stroke care from primordial prevention through recovery. Recognition of the historical barriers to stroke education, underserved at-risk populations, novel educational methodology, and existing social media technology may allow more enduring changes in behavioral responses to both individual and community stroke knowledge.

Recommendations

1. A stroke system should support local and regional educational initiatives to increase stroke awareness (including stroke warning signs, risk factors, primary and secondary prevention, and recovery), aimed at the general population with enriched targeting of populations at increased risk for stroke and poor outcomes after stroke. (New)
2. A stroke system should monitor the effectiveness of community education in improving behavioral responses to warning symptoms, stroke treatment rates, mortality, and other relevant outcomes. (New)
3. Methods to systematically identify and treat risk factors in all patients at risk for stroke should be developed. (New)
4. Innovative behavioral interventions addressing barriers to healthy behaviors, prevention adherence, and warning sign action with tools such as digital phenotype analysis, social network analysis, gamification, and machine learning offer opportunity for sustainable behavioral change, and research in these areas should be encouraged. (Revised from 2005)

Emergency Medical Services

Currently, only ≈50% to 60% of hospitalized stroke patients arrive at the hospital via EMS.[49–51] Racial/ethnic minorities are less likely to use EMS.[52] Given poor stroke awareness among US adults, with the lowest awareness among Hispanics and blacks,[42] lack of knowledge of the risk factors and of the signs and symptoms of stroke remains a hindrance to timely stroke care. After EMS is activated, limitations in the accuracy of prehospital stroke assessment tools and in the timeliness of prehospital care to facilitate access to appropriate hospital care persist.

Prehospital Stroke Screening Tools

Prehospital stroke screening tools remain an important aspect of stroke care. In an Italian study of 18 231 EMS dispatches for stroke-like symptoms, the positive predictive value of the dispatch stroke/TIA symptoms being confirmed on scene by EMS providers was 34.3% (95% CI, 33.7%–35.0%; 6262 of 18 231), and the sensitivity was 64.0% (95% CI, 63.0%–64.9%; 6262 of 9791). Centers that used the Cincinnati Prehospital Stroke Scale (CPSS) more often (ie, >10% of cases) had higher sensitivity (71% [95% CI, 87%–89%] vs 52% [95% CI, 51%–54%]).[53] In a systematic review of prehospital stroke scales performed by EMS providers in the field, both the CPSS (area under the curve, 0.813) and the Los Angeles Prehospital Stroke Screen (area under the curve, 0.964) showed better performance than 5 other field stroke recognition scales.[54] The Los Angeles Prehospital Stroke Screen performed more consistently, but the CPSS had similar diagnostic capability. Of 184 179 US EMS transports with primary impressions of stroke, only 46% met the recommended on-scene time of <15 minutes.[55] Furthermore, hospital prenotification occurs in only 67% of EMS transports.[50] Thus, stroke systems of care should

endeavor to enhance recognition of stroke symptoms by dispatch and EMS providers, to reduce on-scene time in transported patients, and to improve prenotification of the receiving hospital.

Prehospital Stroke Severity Scales and Rerouting of Patients

With the advent of thrombectomy for acute ischemic stroke with large vessel occlusion (LVO) of the internal carotid artery and middle cerebral artery stem (M1) and worse outcomes with delays to thrombectomy,[56,57] ensuring that EMS providers transport patients with acute neurologic deficits to the right hospital for the best treatment as quickly as possible is increasingly critical. At least 6 stroke severity scales targeted at the recognition of LVO in the prehospital setting to facilitate transfer to thrombectomy centers have been published.[58–63] However, all the scales were initially derived from data sets of confirmed stroke cases or selected prehospital cases. Three of the current scales have been tested in the prehospital setting in a limited fashion and without head-to-head comparisons.[64–66] The Cincinnati Stroke Triage Assessment Tool, Rapid Arterial Occlusion Evaluation, Los Angeles Motor Scale, and Field Assessment Stroke Triage for Emergency Destination are specifically named on the AHA Mission: Lifeline severity-based stroke triage algorithm for EMS.[67]

For prehospital patients with suspected LVO by a stroke severity scale, the Mission: Lifeline algorithm recommends direct transport to a CSC if the travel time to the CSC is <15 additional minutes compared with the travel time to the closest PSC or ASRH. At this time, there is insufficient evidence to recommend 1 scale over the other or whether the proposed 15-minute specific threshold of additional travel time for bypass of a PSC or ASRH is optimal. Given the known impact on outcomes of every 15-minute delay of intravenous alteplase,[68] the known impact of delays to thrombectomy,[57] and the anticipated delays in transport for thrombectomy in eligible patients originally triaged to a nonendovascular center, the Mission: Lifeline algorithm is a reasonable approach. Further research is warranted, and prehospital algorithms will need to be updated periodically as new evidence emerges.

MSUs and Prehospital Telemedicine

In the past few years, MSUs have emerged as an innovative approach to facilitating timely stroke care.[69] MSUs are computed tomography (CT)–equipped ambulances that are staffed with a nurse and paramedic, with or without an onboard physician. MSUs without a physician onboard may be supported by a physician available via telemedicine.[70] Ischemic stroke patients may be treated in the prehospital setting with intravenous alteplase, with 31% of subjects treated within the "golden hour" compared with 4.9% in routine care, although this has not been associated with improved outcomes in published reports.[71] Hemorrhagic stroke patients may be identified by CT on the MSU and triaged to an appropriate facility.

Although MSUs have been proliferating in the United States and elsewhere, challenges exist.[72] The implementation and sustaining costs without an established means of reimbursement from the government or third-party payers currently preclude widespread use. At this time, there is insufficient evidence to recommend wide-scale deployment of MSUs. Therefore, ongoing studies should address clinical utility, generalizability constraints, and cost-effectiveness. Further research is warranted, and integration of MSUs into prehospital algorithms will need to be updated periodically as new evidence emerges.

Recommendations

1. Public health leaders along with medical professionals and others should design and implement public education programs focused on stroke systems and the need to seek emergency care (by calling 9-1-1) in a rapid manner. These programs should be repetitive and designed to reach diverse populations. Further research is needed to establish the most effective programs for diverse populations. (New)
2. EMS leaders, in coordination with local, regional, and state agencies and in consultation with medical authorities and local experts, should develop triage paradigms and protocols that ensure that all patients with a known or suspected stroke are rapidly identified and assessed with a validated and standardized instrument for stroke screening such as FAST (Face, Arm, Speech, Time), Los Angeles Prehospital Stroke Screen, or CPSS. (Revised)
   a. In prehospital patients who screen positive for suspected stroke, a standard prehospital stroke severity assessment tool (eg, Cincinnati Stroke Triage Assessment Tool, Rapid Arterial Occlusion Evaluation, Los Angeles Motor Scale, and Field Assessment Stroke Triage for Emergency Destination) should be used to facilitate triage. In the absence of new data, it is reasonable to adapt the Mission: Lifeline algorithm to the needs of the community. Further research is needed to establish the most effective prehospital stroke severity triage scale, which may be one of the published scales or a novel scale or device. (New)
   b. Standardized approaches to prehospital stroke assessment, triage, and management should be encouraged for 9-1-1 call centers and EMS dispatchers. Further research is needed to establish the most effective programs for stroke recognition by 9-1-1 call centers and EMS dispatchers. (New)
3. When there are several intravenous alteplase–capable hospitals in a well-defined geographic region, extra transportation times to reach a facility capable of endovascular thrombectomy should be limited to no more than 15 minutes in patients with a prehospital stroke severity scale score suggestive of LVO. When several hospital options exist within similar travel times, EMS should seek care at the facility capable of offering the highest level of stroke care. Further research is needed to establish travel time parameters for hospital bypass in cases of prehospital suspicion of LVO. (New)
   a. Protocols that include prearrival notification by EMS that a stroke patient is en route should be used in all cases. (New)

Hospital-Based Acute Stroke Management

Given recent advances in the management of acute ischemic stroke, hospital-based acute stroke treatment must involve efficient processes of care to ensure the timely identification

Table 1. Levels and Capabilities of Hospital Stroke Designation

	ASRH	PSC	TSC	CSC
Location	Likely rural	Likely urban/suburban	Likely urban	Likely urban
Stroke team accessible/available 24 h/d, 7 d/wk	Yes	Yes	Yes	Yes
Noncontrast CT available 24 h/d, 7 d/wk	Yes	Yes	Yes	Yes
Advanced imaging (CTA/CTP/MRI/MRA/MRP) available 24 h/d, 7 d/wk	No	Yes	Yes	Yes
Intravenous alteplase capable	Yes	Yes	Yes	Yes
Thrombectomy capable	No	Possibly	Yes	Yes
Diagnoses stroke pathogenesis/manage poststroke complications	Unlikely	Yes	Yes	Yes
Admits hemorrhagic stroke	No	Possibly	Possibly	Yes
Clips/coils ruptured aneurysms	No	Possibly	Possibly	Yes
Dedicated stroke unit	No	Yes	Yes	Yes
Dedicated neurocritical care unit/ICU	No	Possibly	Possibly	Yes

ASRH indicates acute stroke-ready hospital; CSC, comprehensive stroke center; CT, computed tomography; CTA, computed tomography angiography; CTP, computed tomography perfusion; ICU, intensive care unit; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; MRP, magnetic resonance perfusion; PSC, primary stroke center; and TSC, thrombectomy-capable stroke center.

of stroke patients who may benefit from the effective delivery of thrombectomy by qualified providers in the right hospital. Furthermore, cases of large hemispheric or cerebellar ischemic stroke and hemorrhagic stroke, including aneurysmal subarachnoid hemorrhage (SAH), arteriovenous malformations, and spontaneous intracerebral hemorrhage (ICH), must be managed in hospitals with dedicated neurosurgical and neurointensive care services. With this recognition, a 3-tier system of hospital certification has emerged in stroke systems of care over the past 20 years. Recent advances have led to further refinement of stroke hospital systems to include the additional designation of TSCs. In the next sections, we discuss current hospital certification, recent advances in hospital-based stroke management, and emerging solutions to the implementation of scientific advances in routine clinical practice.

Hospital Certification

The Joint Commission, DetNorske Veritas, Healthcare Facilities Accreditation Program, and state health departments across the United States typically designate 3 levels of hospital certification for the management of acute stroke. Terminology varies, but here we use CSC, PSC, and ASRH to represent the highest to lowest level of stroke readiness. All levels of stroke centers should work within their region in an integrated fashion, providing and sharing best practice. Participation in quality improvement processes such as Get With The Guidelines facilitates continuous improvements in care at stroke centers. The ASRH designation is intended to recognize smaller, perhaps remote, community hospitals that have established processes for acute stroke evaluation and treatment, including telemedicine, and well-developed protocols to ensure rapid transfer of stroke patients who require care at higher-level centers to those facilities. ASRHs were created to address gaps in care in regions without PSCs or CSCs but where optimized emergency stroke care can be delivered with guidance from regional PSCs and CSCs. PSCs have efficient processes for the clinical diagnosis of ischemic stroke, safe and timely administration of intravenous alteplase, secondary diagnosis of stroke pathogenesis, and screening for downstream complications. In addition, PSCs provide this care in the context of a defined stroke unit. There are differences in stroke quality of care by certifying organization. An analysis of 477 297 acute ischemic stroke admissions from 977 certified PSCs (74% The Joint Commission, 4% DetNorske Veritas, 1% Healthcare Facilities Accreditation Program, and 21% state based) found that quality was generally similar among the 4 groups, but the rates of alteplase use were higher in The Joint Commission– and DetNorske Veritas–certified hospitals (9.0% and 9.8%) and lower in state-certified and Healthcare Facilities Accreditation Program–certified hospitals (7.1% and 5.9%). Door-to-needle times were significantly longer in Healthcare Facilities Accreditation Program hospitals. State PSCs had higher in-hospital mortality compared with The Joint Commission–certified PSCs.[73] A new level of care has recently been identified to address the need for greater access to thrombectomy in the community: the TSC. This tier sits between a PSC and a CSC. The proper role of TSCs in communities without any access to thrombectomy is straightforward; its role in a community that already has access to a CSC is more controversial, and routing plans for patients with suspected LVO should always seek the center of highest capability when interfacility travel time differences are short. In the United States, there are currently at least 1500 PSCs, ≈200 CSCs, and a growing number of ASRHs. Care at certified stroke centers is associated with improved patient care and outcomes.[16]

CSCs provide the full complement of stroke neurology, critical care, and neurosurgical personnel and infrastructure to manage the most complex ischemic and hemorrhagic stroke patients (Table 1). These tertiary and quaternary facilities serve as centralized centers within mature stroke systems and leverage known volume-outcome relationships in cerebrovascular disease.[74] It remains unknown what impact the new TSC designation will have on thrombectomy experience at the proposed TSCs and current CSCs. Although the total number of cases is expected to increase, insufficient total cases per hospital may dilute local experience and adversely affect patients

because volume of cases is well known to be associated with improved performance.[75,76]

Endovascular Thrombectomy

Multiple randomized clinical trials demonstrated the primacy of rapid thrombectomy with or without intravenous alteplase (depending on alteplase eligibility) for achieving functionally independent outcomes in eligible acute ischemic stroke patients with LVO.[77–81] Furthermore, recent data from 2 extended-window trials indicate that additional patients who are selected with advanced imaging criteria within the 6- to 16-hour or 6- to 24-hour window of last known normal also benefit from thrombectomy.[82,83] Therefore, stroke systems of care should be organized to identify thrombectomy-eligible patients and to deliver such patients to the appropriate hospital in a timely manner, and these hospitals should have processes in place to ensure that thrombectomy-eligible patients are identified and treated quickly and effectively after arrival.

Decompressive Hemicraniectomy

Patients with large completed middle cerebral artery strokes benefit from early decompressive hemicraniectomy. The experience of Schwab et al,[84] the systematic review by Gupta et al,[85] the DESTINY trial (Decompressive Surgery for the Treatment of Malignant Infarction of the Middle Cerebral Artery),[86] and the DECIMAL trial (Decompressive Craniectomy in Malignant Middle Cerebral Artery Infarction)[87] all emphasize the importance of early intervention in maximizing clinical benefit. Data now support both a mortality and functional outcome benefit associated with this intervention. Systems of care must therefore account for the availability of qualified neurocritical care and neurosurgical providers to provide this proven intervention in a timely manner.

Hemorrhagic Stroke

Both SAH and ICH may be associated with life-threatening intraventricular hemorrhage, obstructive hydrocephalus, and intracranial hypertension early in the clinical course. Early placement of an intraventricular catheter for cerebrospinal fluid diversion can be lifesaving. Emergency decompression of cerebellar hemorrhage can also be lifesaving. Thus, transfer of these patients to nonneurosurgical hospitals can be devastating. Furthermore, for aneurysmal SAH (aSAH), surgical clipping or endovascular coiling of the ruptured aneurysm as soon as possible is warranted to reduce the risk of rebleeding. Low-volume hospitals (eg, <10 aSAH cases per year) should facilitate transfer of patients with aSAH to high-volume centers (eg, >35 aSAH cases per year) with experienced cerebrovascular surgeons, endovascular specialists, and multidisciplinary neurocritical care services.[88] For ICH, management at high-volume centers with neurosurgical and neurocritical care has been associated with reduced mortality.[89] Stroke systems of care should ensure that patients with SAH and ICH are cared for at high-volume hospitals capable of ensuring optimized outcomes for these patients, typically hospitals with CSC certification.

Current Challenges, Barriers, and Opportunities

Currently, there is uncertainty about the best thresholds for quality metrics for prehospital recognition of potential patients with LVO (eg, acceptable overtriage rates) and accepted time metrics (eg, door in–door out and PSC puncture to CSC puncture) for patients with LVO triaged to nonthrombectomy centers. "Ideal" times have been proposed.[90] DAWN (Clinical Mismatch in the Triage of Wake Up and Late Presenting Strokes Undergoing Neurointervention With Trevo) and DEFUSE 3 (Endovascular Therapy Following Imaging Evaluation for Ischemic Stroke 3) used various methods of advanced imaging (beyond a simple noncontrast head CT) to identify thrombectomy-eligible patients up to 24 hours since last known normal.[82,83] Although larger hospitals may have the ability to obtain and interpret these images 24 h/d and 7 d/wk, smaller underresourced hospitals may have challenges in obtaining and interpreting these images in a timely fashion. A recent small study suggests that early stroke team activation, CT angiography performed in <30 minutes, and cloud image sharing may reduce door in–door out time and facilitate rapid treatment.[92] Future efforts should be aimed at supporting the widespread implementation of rapid advanced imaging to detect LVO in appropriately selected patients.

Overall, current opportunities for continuing to improve acute stroke care include the following: (1) public education to ensure the patients and families are aware of differences in hospital capabilities; (2) establishment of best practices that ensure that low-volume/inexperienced centers have processes in place to facilitate transport to more experienced centers or to ensure optimized care for patients who may be appropriately retained at the low-volume center; (3) prehospital assessment tools to allow effective identification and triage among levels of care; (4) accepted training standards for the certification of qualified interventionalists to provide thrombectomy; (5) ensuring an adequate supply of qualified interventionalists; (6) existing capital infrastructure and imaging capabilities at centers currently caring for stroke patients; and (7) development of and transparent sharing of processes of care and outcomes, depending on the capabilities of the center and allowing for appropriate risk adjustment and comparison.[93,94]

Emerging Solutions

The CSC, TSC, PSC, and ASRH certification standards provide a strong platform for the introduction of data-driven improvements in hospital-based acute stroke care. Increased participation in these processes or mirroring by local, county, and state systems would foster improved process and outcome quality. Establishing evidence-based acceptable prehospital overtriage rates and treatment/transfer time metrics at nonthrombectomy centers, coupled with technical angiographic results and procedural complication profiles, could reproduce previous successes in PSC networks for stroke, ST-segment–elevation myocardial infarction networks for myocardial infarction, and American College of Surgeons Verification, Review, and Consultation Program.

Access and Workforce for Acute Stroke Thrombectomy in the United States

An estimated 27 000 to 97 000 patients may be eligible for thrombectomy annually in the United States.[95] Access to acute stroke intervention for patients with LVO in the United States has evolved in the past decade. In 2011, 56% and 85% of the US population had access to endovascular thrombectomy-capable hospitals within an hour by ground and air, respectively.[96] Recent modeling data, with an assumption of the

addition of 5 to 20 optimally located CSCs per state, estimate that 63% of the US population would have ground access to thrombectomy centers within an hour and 83% would have ground/air access within an hour.[97] Furthermore, workforce demand-supply for thrombectomy is in a rapid state of evolution. Figures 2 and 3 show the geographic dispersion in the United States to thrombectomy-capable and endovascular-capable centers.

The Committee on Advanced Subspecialty Training of the Society of Neurological Surgeons has undertaken the certification of neuroendovascular training programs in conjunction with the Society of NeuroInterventional Surgery and the Society of Vascular and Interventional Neurology.[98] These standards represent the collaborative efforts of neurological surgery, interventional neuroradiology, and interventional neurology in adopting uniform standards and complement previous guidelines by the Accreditation Council for Graduate Medical Education.[99] Over time, these standards will provide a more uniform set of expectations for endovascular performance. More data are needed for monitoring evolutions in access to care and available workforce to facilitate such access.

Recommendations

1. The CSC, PCS, TSC, and ASRH framework provides an appropriate platform for the data-driven development of hospital-based processes of care and outcome metrics. All certification systems should meet or exceed these standards. All levels of stroke centers should work within their region in an integrated fashion, providing and sharing best practice. (New)
   a. TSC is a new hospital designation. Evidence supporting timely identification and treatment of thrombectomy-eligible ischemic stroke patients at TSCs is warranted. TSC treatment processes, technical outcomes (reperfusion rates), complications, and patient clinical outcomes should be tracked and reported.
   b. Both the clinical benefit of decompressive craniectomy and the management of hemorrhagic stroke merit systems consideration of neurosurgical and neurocritical care resources in developing comprehensive systems for high-acuity stroke patients.
2. Identification of candidates for thrombectomy requires the timely completion of parenchymal and arterial imaging (CT or magnetic resonance) to identify the subset of patients who may benefit from thrombectomy. All centers

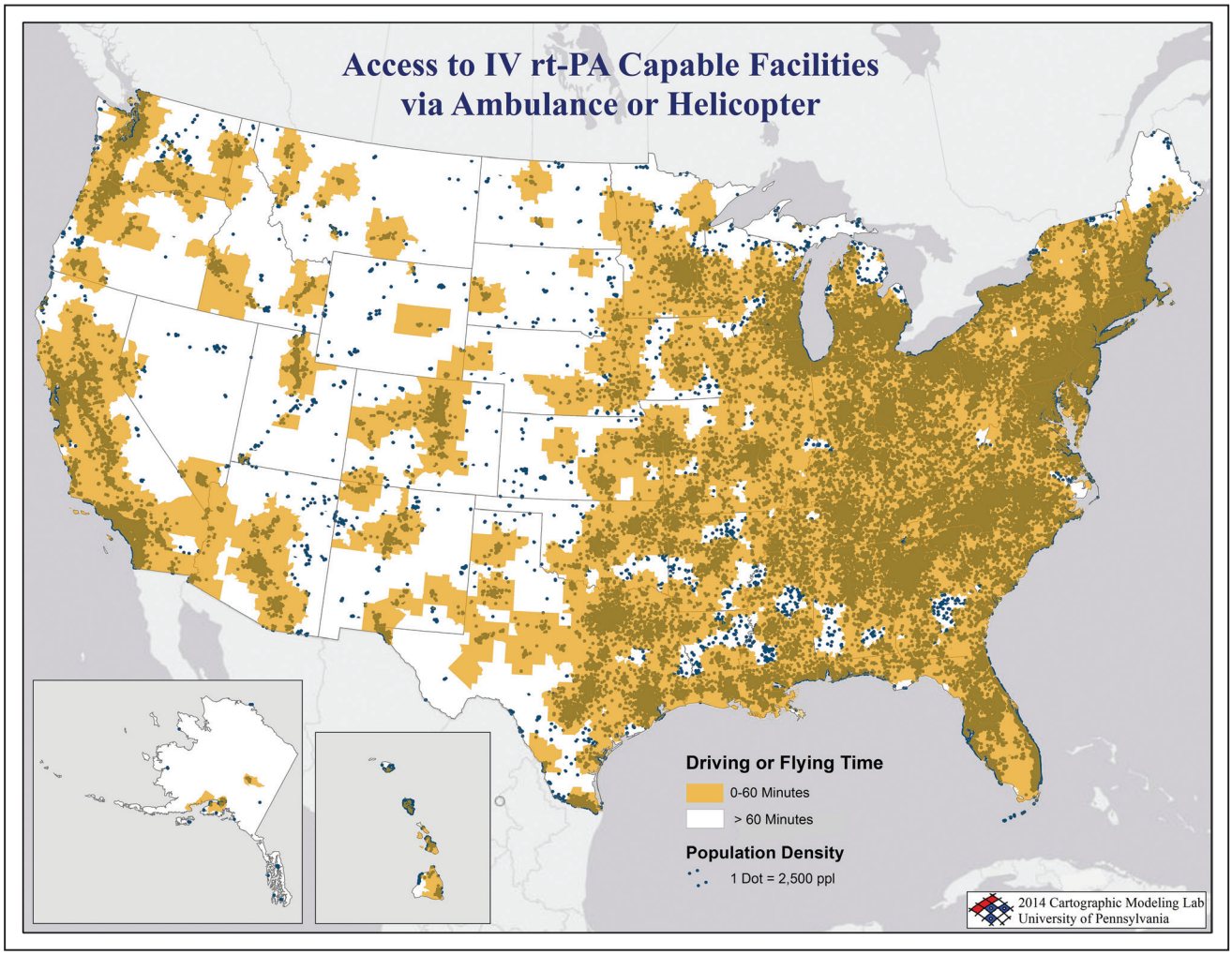

Figure 2. Access by ground or air to intravenous (IV) alteplase–capable hospitals within 60 minutes. pp indicates people; and rt-PA, recombinase tissue plasminogen activator. Reproduced from Adeoye et al.[96] Copyright © 2014, American Heart Association, Inc.

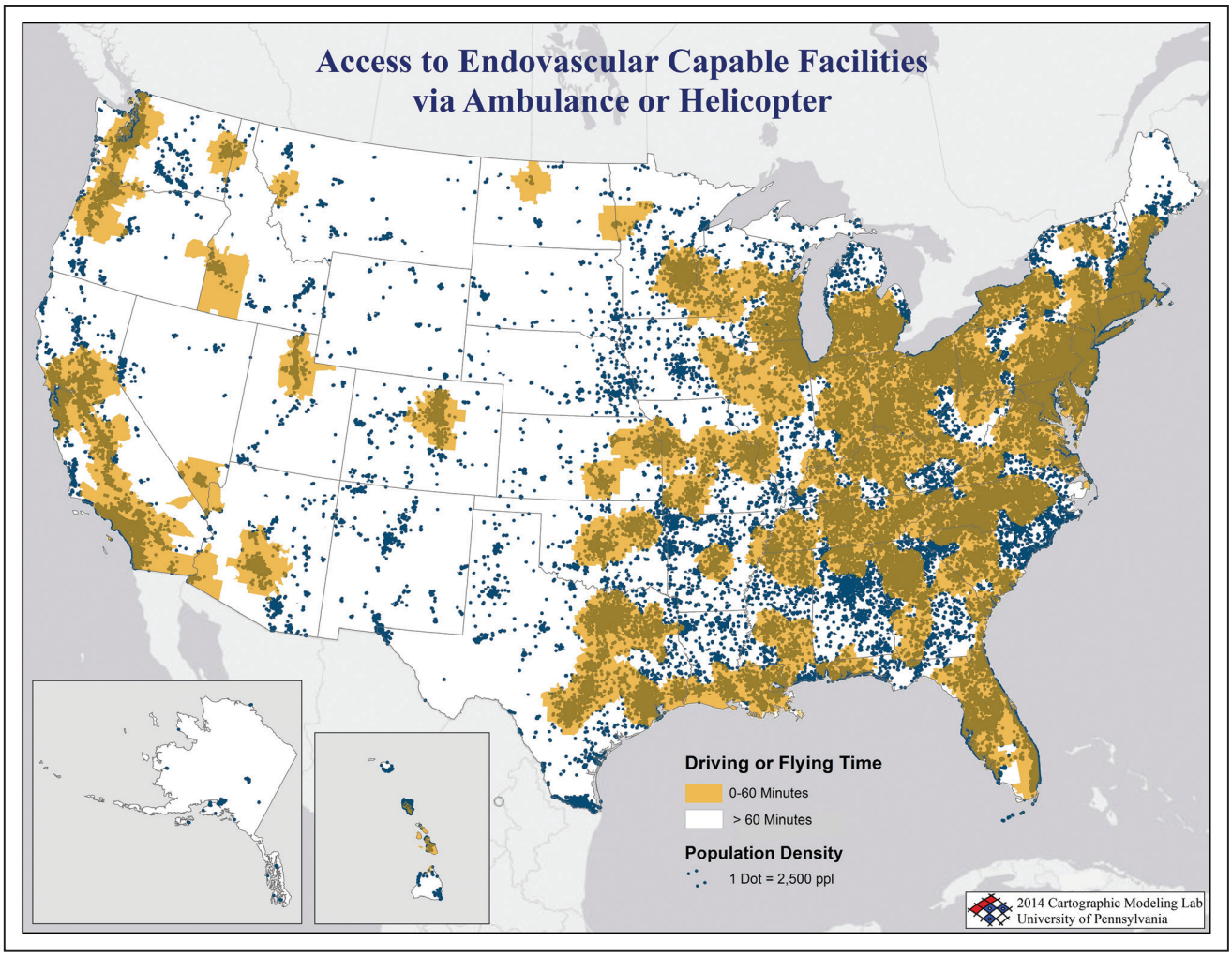

Figure 3. Access by ground or air to endovascular-capable hospitals within 60 minutes. ppl indicates people. Reproduced from Adeoye et al.[96] Copyright © 2014, American Heart Association, Inc.

managing stroke patients should develop a plan for the definitive identification and treatment of these patients. Hospitals without thrombectomy capability should have transfer protocols to allow the rapid treatment of these patients at hospitals with the appropriate level of care. In some instances (eg, rural facilities without imaging and radiology capabilities 24 h/d and 7 d/wk), this may mean rapid transfer of patients with clinically suspected LVO to hospitals where their workup may be expedited. (New)

3. Centers providing thrombectomy should rigorously track patient flow at all time points from presentation to imaging to intervention to allow iterative process improvement. Technical outcomes (reperfusion rates), procedural complications, and patient clinical outcomes must be tracked and reported. (New)
4. Data suggest the benefit of more sophisticated imaging triage that assesses penumbral pattern in selecting patients for endovascular thrombectomy from 6 to 24 hours from last known normal. These data merit the broader adoption of this imaging technology in thrombectomy centers. (New)
5. Certification standards for endovascular training programs and individuals provide a means for monitoring the adequacy and qualification of the endovascular workforce. The TSC designation adds new structure, monitoring, and transparency for the requirements for stroke neurointerventionalists.

Secondary Prevention/Postacute Care

The postacute period of the stroke continuum is critical because of the importance of early rehabilitation to enhance recovery, improved transitions of care to reduce readmission, and early follow-up to continue and refine secondary prevention to reduce recurrent stroke risk. Secondary prevention of stroke has improved over the past 5 decades, mostly as a result of improved use of antithrombotic therapy and blood pressure management.[100] Since the previous publication, inpatient quality measures have been instituted that are required by all hospitals for public reporting purposes. This has resulted in a more standardized approach to subacute stroke care, and adherence to these measures has improved over time.[101] For postacute stroke, the Centers for Medicare & Medicaid Services (CMS) mandated all-cause 30-day readmissions penalties for hospitals that exceed the national risk-adjusted readmission rate in 2016.[102] Recent evidence has shown that a small proportion of

readmissions are preventable[103] and that some planned readmissions may be warranted but still are penalized according to the CMS definition.[104] Advocates for further refinement of the determination of 30-day readmission rates (and other quality measures) are concerned that the calculation of readmission rates without initial stroke severity (ie, the National Institutes of Health Stroke Scale) will lead to misclassification of hospital performance and therefore misappropriation of resources.[93] Although the focus of processes to reduce readmissions has been on hospital-related factors, the social, functional, and community determinants of health are likely to be factors important in later (>7 days after discharge) readmissions that appear to be unrelated to hospital quality.[105] Given the uncertain impact of making changes to processes of care to reduce readmissions, the focus of postacute care should be on reducing mortality, maximizing recovery, and preventing recurrent stroke and cardiovascular events.

A comprehensive pathway for stroke care called the Global Stroke Services Action Plan was published in 2014.[106] This action plan is inclusive of the US stroke quality measures but is more extensive because it covers stroke care across the continuum. For transitions of care, the action plan recommends, "Patients, families, and informal caregivers should be provided with information, education, training, emotional support, and community services specific to the transition they are undergoing."[106] Although this practice is likely commonly achieved in the inpatient rehabilitation setting before discharge, it is less common on discharge from the acute hospital setting, where the length of stay may be ≤4 days.

Despite the progress that has been made in the past 10 years, there are still gaps in and challenges and barriers to improving postacute care and secondary prevention. One of these barriers is the lack of structure in the paths that stroke patients and caregivers experience. An important aspect of postacute specialized care is screening for and avoiding stroke complications, which can include falls, venous thromboembolism, recurrent stroke or TIA, extension of an existing infarct, hypotension/hypertension, infections, cardiac complications, dehydration, and renal failure. Although some of these complications are addressed in the hospital with current quality metrics, there are no US hospital measures of the quality of postacute care designed to reduce these complications and to ensure that secondary prevention is followed after discharge. However, the Global Stroke Services Action Plan provides an evidence-based framework for hospitals to meet these specific quality indicators.[106]

Access to postacute stroke services is another major barrier to equitable outcomes after stroke. There is wide geographic variation in access to postacute services for stroke patients, particularly postacute facilities and home health care.[107] A study of contemporary trends from 2003 to 2011 showed that overall 44% of patients are discharged home without any postacute services.[108] Alarmingly, 65% of stroke survivors <65 years of age were discharged without any postacute care services.[108] In addition, geographic disparities have been assumed to affect the quality of stroke prevention. However, the designation as a health professional shortage area was not associated with statin use, as shown in the REGARDS study. In fact, the lack of insurance appeared to decrease the likelihood of adequate access to stroke prevention medications, not designation as a health professional shortage area region alone.[109] The variation in access to services based on insurance (or lack thereof) and age <65 years suggests that many patients who should receive services are denied access, and this could have a significant negative effect on both recovery and secondary prevention.

Stroke education is an essential part of the postacute transition and includes not only what to do if stroke symptoms recur but also how to manage stroke risk factors; medications; appointments for primary care, specialists, and therapy; home safety; and lifestyle changes. Stroke education at discharge is a quality measure and publicly reported. However, stroke education in the postacute transition is even more important because of the overwhelming amount of information that patients and caregivers receive during their hospital stay and the information needed to adapt to the community.[110] A recent scoping review of postacute services for patients with mild stroke concluded that services that provide education related to maximizing participation in secondary prevention is an area (among several) that requires more development and assessment in this population.[111]

Emerging solutions to these challenges and barriers are on the horizon. A model of transitional care provided by a trained stroke nurse practitioner and a registered nurse showed that a systematic assessment of stroke complications reduced 30-day readmissions.[112] After adjustment for important confounders, being seen in this specialized transition clinic was associated with a nearly 50% reduction in 30-day readmissions compared with not being seen there.[112]

Early supported discharge is another model of transitional care in which patients are discharged home early and receive rehabilitation and specialized stroke services from a hospital-based multidisciplinary team that includes physical and occupational therapists, nurses, a social worker, a stroke neurologist, and personal aides.[113] An important premise of early supported discharge is the use of community services. Stroke systems of care should be connected not only with outpatient therapy and home health care but also with other services that can support patients and caregivers and allow sustained improvement,[114] similar to the recommendations of the Global Stroke Action Plan.[106] These services include community exercise programs, fall prevention programs, behavioral health, pharmacy services, stroke/caregiver support groups, risk factor self-management, local agencies that provide nutrition and transportation services (such as provided by the Area Agency on Aging), and handoffs to primary care.[113]

A new model of care that includes a patient-centered approach to both postacute care and secondary prevention is the Comprehensive Post-Acute Stroke Services model, currently being compared with usual care in 41 hospitals across North Carolina in a cluster-randomized pragmatic clinical trial.[115] This model screens for postacute complications but also assesses the medical, social, and functional determinants of health and provides each patient with an individualized care plan that includes only the services needed for that patient at the point of care. A unique facet of this program involves the development of a community resource network

located at each hospital participating in the trial, so that services can be mapped to a patient on the basis of what is available to that patient locally. The primary outcome of this trial is functional status, but rates of 30-day readmissions and multiple aspects of secondary prevention will also be determined.

The use of community health workers is also an emerging trend in healthcare services in the United States. In a systematic review of 34 published studies, the overall impact of community health worker intervention was variable, but 5 randomized trials showed a significant reduction in ≥1 emergency department visits, hospitalizations, or urgent care visits.[116] The ongoing SUCCEED trial (Secondary Stroke Prevention by Uniting Community and Chronic Care Model Teams Early to End Disparities) will provide evidence for the use of an advanced practice clinician–community health worker team for secondary prevention after stroke.[117]

Recommendations

1. Stroke centers should use organized approaches (eg, stroke teams, stroke units, and written protocols) to ensure that all patients receive appropriate subacute care. (Revised from 2005)
2. Stroke centers should adopt approaches to secondary prevention that address all major modifiable risk factors and that are consistent with the national guidelines for all patients with a history or a suspected history of stroke or TIA. The focus of postacute care should be on reducing mortality, maximizing recovery, and preventing recurrent stroke and cardiovascular events. (Revised from 2005)
3. A stroke system should establish support systems to ensure that all patients discharged from hospitals and other facilities to their homes have appropriate follow-up with specialized stroke services when needed and primary care arranged on discharge. These efforts should include education and training for the patient and his or her family members. Clear, comprehensive, and timely communication across the inpatient and outpatient poststroke continuum of care is essential to ensure appropriate medical and rehabilitation care. (New)
4. To standardize postacute care after stroke discharge, stroke centers should comprehensively screen for postacute complications, provide individualized care plans for patients during the transition of care, provide referrals to community services, and reinforce secondary prevention and self-management of stroke risk factors and lifestyle changes to decrease the risk of recurrent stroke. Trained stroke nurses, nurse practitioners, social workers, community health workers, and others should play a pivotal role. (New)

Rehabilitation and Recovery of Stroke Survivors

Rehabilitation remains the primary means by which a stroke survivor recovers maximal function. As shown in Table 2, stroke rehabilitation and recovery occur in various care settings.[119]

The Commission on Accreditation of Rehabilitation Facilities developed a Stroke Specialty Program that encompasses inpatient, outpatient, home and community, residential, and pediatric rehabilitation programs. Standards seek to minimize impairments, secondary complications, and environmental barriers; to reduce activity limitations; to maximize participation and quality of life; and to prevent recurrent stroke. The Joint Commission Disease-Specific Care Certification in Stroke Rehabilitation uses performance improvement to identify and address improvement opportunities, implements and graphically depicts a performance plan over time, and reviews the effectiveness of the interventions implemented in response to improvements identified by measurement activity.

Practice guidelines for stroke rehabilitation are well established and recommend that stroke survivors receive rehabilitation at an intensity commensurate with anticipated benefit and tolerance.[118] However, access to rehabilitation services remains a major barrier. Availability of postacute care settings (especially in underserved areas), prospective payment variability, regulatory practices, the pressure to discharge patients rapidly from acute care, race, ethnicity, and sex all may influence if and where rehabilitation services are provided.[107,120–126] Uninsured stroke survivors may remain in acute care longer because of problems in transferring them to inpatient rehabilitation settings.[127] Thus, it is not surprising that a recommendation from the "Interactions Within Stroke Systems of Care" policy statement emphasizes that "…all patients have access to post-stroke care (discharge planning services, rehabilitation, nursing facilities, medical follow-up) regardless of their financial status or socioeconomic background."[2]

How stroke survivors are assessed for rehabilitation may also be problematic. Although PSC standards require that stroke survivors be assessed for rehabilitation services, 60.4% of stroke survivors <65 years of age and 37.5% of those ≥65 years of age were discharged home without rehabilitation services between 2003 and 2011.[108] There are many reasons for this phenomenon. Providers may be tempted to use no measurable deficits on the National Institutes of Health Stroke Scale as a guide to determine the need for rehabilitation services, but stroke survivors scoring a zero on the National Institutes of Health Stroke Scale may exhibit discernible motor deficits on the upper limb Fugl-Meyer and the Arm Motor Ability Test,[128] as well as truncal ataxia, headache, vertigo, and nausea after posterior circulation strokes.[129] Thus, standardized neurological, functional, and psychosocial assessments are needed to ensure that these and other issues are not missed.

Finally, a single dose of postacute rehabilitation does not meet the needs of all stroke survivors. Sufficient evidence has demonstrated that chronic stroke patients benefit from additional rehabilitation therapy.[130,131] Existing models of the prediction of rehabilitation potential explain less than half of the variance in recovery after stroke.[132] Thus, stroke survivors need to be assessed functionally throughout their lifetimes to prevent readmission, to maintain fitness, and to prevent secondary complications.[133]

Table 2. Stroke Rehabilitation Levels of Care[119]

Location	Patient Population	Services Offered
Inpatient rehabilitation facility	Need close medical supervision	Hospital-level care directly supervised by a physician
	Able to participate in at least 3 h of therapy per day 5 d/wk (or, in certain cases, at least 15 h of therapy within consecutive 7-d periods)	Physical, occupational, and speech therapy
	Not expected to need institutional care	Specialized nursing and social services
Skilled nursing facility	Need skilled nursing care	Rehabilitation nursing on site
	Able to participate in therapy for <3 h/d up to 5 d/wk to improve functional ability	Care plan provided by a physician
		Occupational, speech, physical, and other therapy as needed
Long-term acute care hospital	Have multiple chronic conditions	Extended comprehensive rehabilitative services
	Need hospital-level care for an average of ≥25 d	Highly specialized medical care
Nursing home	Do not require skilled nursing	Long-term care for patients who cannot live independently
Outpatient clinic	Do not require inpatient care	Hospital-based or free-standing sites
	Able to leave home for therapy	Transition of care to primary care provider
		Occupational, speech, and physical therapy
Home health agency	Must be homebound except for medical appointments	Transition of care to primary care provider
		Skilled nursing
		Occupational, speech, and physical therapy
		Health aide
		Social services

Recommendations

1. A stroke system should ensure that all stroke survivors receive a standardized screening evaluation during the initial hospitalization to determine whether rehabilitation services are needed and the type, timing, location, and duration of such therapy. Long-term primary care and specialist (physiatrist or neurology) follow-up should be arranged to identify patients with residual impairments so that these patients receive appropriate continued rehabilitation. (New)

The use of a standardized evaluation provides important insights into the type and duration of rehabilitation therapy needed on a patient-by-patient basis. Evaluations for stroke rehabilitation should include a neurological assessment of residual deficits; an assessment of functional (activities of daily living), cognitive, and psychological status; and determination of previous functional status and medical comorbidities, the level of family/caregiver support, the likelihood of returning to community living, and the ability to participate in rehabilitation services.

2. A stroke system should periodically assess its level of available rehabilitation services and community resources. (New)

Such an assessment should include the total number and types of beds available, the intensity of services provided in different settings, the presence of interdisciplinary coordinated teams, including the use of community health workers, and the adequacy of care coordination programs. This assessment should consider the current and future needs in the system for inpatient and outpatient care, including the relative mix among inpatient rehabilitation facilities, skilled nursing facilities, continuing-care retirement communities, home care services, and outpatient services.

3. A stroke system should establish support systems to ensure that patients discharged from hospitals and other facilities to their homes have appropriate follow-up and primary care arranged on discharge. (New)

The stroke system should ensure that patients are referred to the setting most appropriate to their clinical needs.

Palliative and End-of-Life Care

Of the nearly 800 000 reported strokes per year, ≈16% of patients will die of their stroke within the first 30 days. Of the nearly 6 million Americans who have survived a stroke, ≈30% are left with permanent disabilities. Given the serious and complex challenges they face, stroke survivors and their caregivers can benefit from palliative care that can be provided at any level of stroke care and optimizes quality of life throughout the continuum of stroke care by reducing suffering, promoting comfort, and preserving dignity. Therefore, the 2014 AHA/ASA scientific statement that addresses palliative and end-of-life care in stroke emphasizes that palliative care has much to offer when stroke care is clinically challenging and emotionally intense and when ethically complex medical choices are encountered.[134] Palliative care is not an alternative to offering life-sustaining therapies but supplements and enhances care delivery for stroke survivors, caregivers, and providers alike when facing serious illness.[134]

Special Considerations

Telemedicine

Over the past decade, telestroke consultation has flourished and spread worldwide. Several publications by the AHA and

others have summarized the evidence supporting telestroke and addressed the value and cost-effectiveness of telestroke in enhancing access to care within a stroke system of care.[4,135,136] Telestroke has been shown to increase rates of thrombolysis, particularly at hospitals without stroke units, without increasing the rates of adverse events compared with patients treated initially at tertiary care stroke centers.[137,138] Approximately 25% of thrombolysis in the United States in the Get With The Guidelines–Stroke registry occurs in a drip-and-ship model, and a large proportion of this activity is likely supported by telestroke consultation.[139] Telestroke also plays an important role in cerebrovascular care beyond ischemic stroke and thrombolysis decision making. Telestroke networks, as part of a stroke system of care, may help shorten hospital length of stay through advanced care, avoid a large number of unnecessary transfers, identify specific stroke patients who require urgent interventions or surgery (eg, patients with aSAH, those with intraventricular hemorrhage, candidates for craniectomy, or patients with LVO), establish stroke units and stroke teams in spoke hospitals, and eradicate disparities by delivering expertise where it is needed, whether in high-, middle-, or low-income countries.[140]

More recently, quality measures have been proposed for telestroke to ensure that the highest standards of care are maintained with the broader dissemination of this technology.[141,142] These include infrastructure (eg, technical characteristics of the system, adherence to privacy regulations, adequate training and supervision, documentation practices), processes of care (eg, timeliness of care, rates of alteplase use), and performance criteria (eg, patient outcomes, patient satisfaction, safety events, technical failure rates). The recommendations stress that the use of widely accepted industry technology standards is encouraged and that the care provided during telestroke consultation should be similar to that given during on-site consultation.

Results from a recent clinical trial from the National Institutes of Health StrokeNet consortium showed that telemedicine-enabled rehabilitation (telerehabilitation) increases access to high-quality poststroke rehabilitation. As telestroke programs have proliferated, costs have reduced and a variety of alternative models for delivery have emerged from for-profit vendors, academic medical center networks, private practitioners, and others.[137] Telestroke services have evolved from their initial focus on the acute thrombolysis encounter to incorporate post-alteplase follow-up care, nonurgent consultation, and supporting care to remain local at lower-cost facilities when appropriate. In an exciting new development, 4G mobile broadband has enabled telestroke consultation into the prehospital arena, with MSUs in the United States deploying telemedicine and teleradiology to support acute care decision making and thrombolysis through remote consultation in specially equipped EMS vehicles.[70,143] Others are reporting small-scale clinical trials of handheld interactive video in traditional ambulances to improve stroke recognition and triage.[144,145]

Given anticipated increases in computing power with the increasing speed and availability of wired and mobile broadband, it is likely that the next decade will be one of continued medical technology innovation. We are likely to see novel technologies interwoven into traditional workflows to create new avenues of care delivery and more seamless escalation and integration among phone, video, image, and data sharing. Telemedicine will be ubiquitous as passive and active monitoring of our daily health behaviors is integrated into smartphone apps with risk prediction models and decision-support algorithms that will trigger medical interventions. The power of these tools to promote healthy lifestyles and to increase adherence to secondary prevention of stroke and cardiovascular disease is untapped and may ultimately have a large impact on stroke systems of care.[146]

Patient-Reported Outcomes

Stroke is a global epidemic with a disproportionate burden among low-income countries.[147] There is an urgent need to deliver more efficient and effective care that increases the value that health care provides to patients. Value in stroke care has been defined as the total benefit gained by a patient relative to the cost of obtaining that benefit (ie, stroke health outcomes divided by the cost to achieve those outcomes).[148] Defining stroke-specific measurable outcomes that are meaningful to patients is critical to this equation and requires deep participation by patients to properly select the outcome measures. Initial efforts to create a utility-weighted version of the modified Rankin Scale score to better reflect the ordinal steps between each level have been published.[149,150] The Stroke Impact Scale, Stroke-Specific Quality of Life Scale, health-related quality of life, and EuroQol 5-Dimensions Questionnaire are also validated measures focused on outcomes that are meaningful to patients.[151–154]

Alternatively, outcomes can be broken into the broad categories of survival, disease control, complications of treatment, and long-term quality of life.[155] The importance of each can vary from patient to patient, between patient and caregiver, across diseases, and at different stages of disease and illness.[156] Despite existing efforts in the area of patient-reported outcome measures to quantify stroke outcomes accurately with validated instruments, there is significant variability across instruments and domains, as well as no agreement about which critical measures should be routinely captured.[157] It is also important to distinguish between metrics that are provider assessed versus patient self-reported. To define a set of global standards for measuring outcomes that matter most to stroke patients, an international expert panel was assembled representing patients, advocates, and clinician experts in stroke outcomes, registers, global health, epidemiology, and rehabilitation.[158]

The result was an international standard set of stroke patient-reported outcome measures that prioritized inclusion of risk adjustment variables, pragmatism over idealism, and completeness in data collection over breadth of areas surveyed and permitted retrospective abstraction and instruments that are perpetually freely available, permit recombination of elements, and are robust for comparison in both low- and high-income countries, with available cost utility values to calculate measures of cost-effectiveness.[159] The Patient Reported Outcomes Measurement Information System 10-question short form is freely available in analog or digital format, is

available in multiple languages, and can be converted to other scores of established instruments for comparison: the Short Form 36-Question Health Survey, the modified Rankin Scale, the Barthel Index, and the widely used EuroQol 5-Dimensions Questionnaire, which also allows calculation of quality-adjusted life-years.[160,161]

Transitions of Care

With stroke survivors potentially receiving care from multiple providers in different settings, transitions in care remain a major challenge. These transitions include the following: from prehospital to the admitting hospital, from the intensive care unit to the hospital floor, from the hospital to postacute settings (inpatient rehabilitation, skilled nursing facility, long-term acute care hospital, or home), and from a facility to home. Handoffs between providers occur at each transition point. Causes of ineffective transitions of care include breakdowns in communication, patient education, and accountability. Expectations may differ between senders and receivers of stroke survivors in transition. A lack of teamwork and respect may hinder the culture required to promote a successful handoff. An inadequate amount of time may be provided to complete the handoff. Stroke systems of care may lack standardized procedures and performance measures to address handoffs. Ineffective care transition processes may result in adverse events and higher hospital readmission rates and costs.[162–164] Electronic health record "rounding lists" that are populated automatically (reducing human error) and can be shared by providers at each hospital-based transition should be more widely adopted. Emerging approaches to facilitating transitions of care and reducing readmission rates include the use of nurse navigators, as discussed in the Secondary Prevention/Postacute Care section, or social workers, which is being evaluated in a clinical trial funded by the Patient-Centered Outcomes Research Institute.[165] For interfacility transitions, opportunities to break down the barriers in communication include the use of remote monitoring such as telemedicine.

Regulatory Issues in Stroke Systems of Care

In the United States, no federal legislation currently organizes or standardizes stroke care throughout the continuum. The Stroke Treatment and Ongoing Prevention Stroke Act of 2001,[166] introduced in the US Senate in late 2001, called for increases in stroke prevention and treatment knowledge and awareness activities, the creation of a national stroke registry, and grants to train professionals and to create telestroke networks, but it did not pass in the 107th or 108th Congresses. In 2017, several pieces of legislation were introduced that seek to remove barriers for Medicare reimbursement of telestroke. The Furthering Access to Stroke Telemedicine Act of 2017,[167] which was signed into law in early 2018, removes rural limits and expands Medicare coverage of telestroke services nationwide. The Creating High-Quality Results and Outcomes Necessary to Improve Chronic Care Act[168] also seeks to remove these barriers and is currently in the House after receiving a unanimous vote of approval in the Senate. For rehabilitation, CMS defines the scope of inpatient rehabilitation facilities, skilled nursing facilities, long-term acute care hospitals, home health agencies, and hospices. CMS coverage of services and payment, admission, and billing procedures is described in detail. However, CMS does not oversee or facilitate the organization of these facilities. Thus, postacute care of stroke survivors remains fragmented.

Some cities and states have taken responsibility to establish acute stroke systems of care. To date, 21 states have enacted statewide standards for the formal recognition of stroke facility designations and the development of transport protocols; 16 have passed legislation that requires stroke centers to participate in statewide stroke care data registries; and others have passed or may pass legislation that standardizes stroke practices such as prehospital and EMS treatment protocols.[169] Cities such as Chicago have implemented prehospital stroke triage policies that have significantly improved prenotification and EMS use.[170] However, standards and accrediting bodies may differ among states, thereby causing variations in the rates of use of alteplase and door-to-needle times. Thus, acute stroke quality of care and outcomes may vary greatly.[73] For stroke rehabilitation, no state has legislated or set policy for standards of stroke rehabilitation triage and care. Thus, case managers report that rehabilitation bed availability, facility location, and "the speed with which you are able to discharge a stroke patient [to a facility]" affect where stroke survivors ultimately are discharged.[124]

Healthcare disparities also remain a significant issue in navigating stroke systems of care. For acute stroke, uninsured patients have longer lengths of stay compared with insured patients, largely because of the inability to transfer uninsured patients to inpatient rehabilitation settings.[127] In Get With The Guidelines–Stroke, patients with ICH demonstrated differences in mortality, functional status, discharge destination, and quality-of-care measures associated with insurance status.[171] For rehabilitation, insurance is the single greatest barrier in referring stroke survivors to the most appropriate level of postacute care and a significant barrier in referring stroke survivors to the most appropriate specific facility. Racial and ethnic minority groups are less likely to receive postacute rehabilitation after stroke.[125,126] Thus, reforms are required to provide better access and more standardized care to stroke survivors throughout the continuum, resulting in fewer disparities in quality of stroke care and functional outcomes. A concerning development in the United States is insurance companies denying payment for conditions deemed not an emergency on the basis of the ultimate diagnosis, not on the symptoms that prompted the visit to the emergency department.[172,173] An increasing frequency of such denials may affect patients' willingness to seek emergency care given the potential financial implications.

Recommendations

1. Efforts should be made to advance the use of technology and patient-reported outcomes and to facilitate improved care transitions in stroke care. These interventions should be refined on the basis of continuous quality improvement measurement and methods. Such efforts not only will bolster overall stroke prevention, treatment, and recovery but also may reduce the persistent

disparities observed in stroke care. Before implementation, new policies should be evaluated for potential adverse impacts on access to care and disparities in care. (New)

2. Federal or other governmental institutions should enact policies that standardize the organization of stroke care throughout the continuum. Such policies should aim to lower barriers to seeking emergency care for stroke, to ensure that stroke patients receive care at appropriate hospitals in a timely manner, and to facilitate access to secondary prevention and rehabilitation and recovery resources after stroke. (New)

Summary of Recommendations for Stroke Systems of Care

1. A stroke system should support local and regional educational initiatives to increase stroke awareness (including stroke warning signs, risk factors, primary and secondary prevention, and recovery), aimed at the general population with enriched targeting of populations at increased risk for stroke and poor outcomes after stroke.
2. Innovative behavioral interventions addressing barriers to healthy behaviors, prevention adherence, and warning sign action with tools such as digital phenotype analysis, social network analysis, gamification, and machine learning offer opportunity for sustainable behavioral change, and research in these areas should be encouraged.
3. Public health leaders, along with medical professionals and others, should design and implement public education programs focused on stroke systems and the need to seek emergency care (by calling 9-1-1) in a rapid manner. These programs should be repetitive and designed to reach diverse populations. Further research is needed to establish the most effective programs for diverse populations.
4. EMS leaders, in coordination with local, regional, and state agencies and in consultation with medical authorities and local experts, should develop triage paradigms and protocols that ensure that all patients with a known or suspected stroke are rapidly identified and assessed with a validated and standardized instrument for stroke screening such as FAST (Face, Arm, Speech, Time), Los Angeles Prehospital Stroke Screen, or CPSS.
   a. In prehospital patients who screen positive for suspected stroke, a standard prehospital stroke severity assessment tool (such as the Cincinnati *Stroke* Triage Assessment Tool, Rapid Arterial Occlusion Evaluation, Los Angeles Motor Scale, and Field Assessment *Stroke* Triage for Emergency Destination) should be used to facilitate triage. In the absence of new data, it is reasonable to adapt the Mission: Lifeline algorithm to the needs of the community. Further research is needed to establish the most effective prehospital stroke severity triage scale, which may be one of the published scales or a novel scale or device.
   b. Standardized approaches to prehospital stroke assessment, triage, and management should be encouraged for 9-1-1 call centers and EMS dispatchers. Further research is needed to establish the most effective programs for stroke recognition by 9-1-1 call centers and EMS dispatchers.
5. The CSC, PSC, TCS, and ASRH framework provides an appropriate platform for the data-driven development of hospital-based processes of care and outcome metrics. All certification systems should meet or exceed these standards. All levels of stroke centers should work within their region in an integrated fashion, providing and sharing best practice.
   a. TSC is a new hospital designation. Evidence supporting timely identification and treatment of thrombectomy-eligible ischemic stroke patients at TSCs is warranted. TSC treatment processes, technical outcomes (reperfusion rates), complications, and patient clinical outcomes should be tracked and reported.
   b. Both the clinical benefit of decompressive craniectomy and the management of hemorrhagic stroke merit systems consideration of neurosurgical and neurocritical care resources in developing comprehensive systems for high-acuity stroke patients.
6. Stroke centers should adopt approaches to secondary prevention that address all major modifiable risk factors and that are consistent with the national guidelines for all patients with a history or a suspected history of stroke or TIA. The focus of postacute care should be on reducing mortality, maximizing recovery, and preventing recurrent stroke and cardiovascular events.
7. A stroke system should establish support systems to ensure that all patients discharged from hospitals and other facilities to their homes have appropriate follow-up with specialized stroke services when needed and primary care arranged on discharge. These efforts should include education and training for the patient and his or her family members. Clear, comprehensive, and timely communication across the inpatient and outpatient poststroke continuum of care is essential to ensure appropriate medical and rehabilitation care.
8. To standardize the postacute care after stroke discharge, stroke centers should comprehensively screen for postacute complications, provide individualized care plans for patients during the transition of care, provide referrals to community services, and reinforce secondary prevention and self-management of stroke risk factors and lifestyle changes to decrease the risk of recurrent stroke. Trained stroke nurses, nurse practitioners, social workers, community health workers, and others should play a pivotal role.
9. A stroke system should ensure that all stroke survivors receive a standardized screening evaluation during the initial hospitalization to determine whether rehabilitation services are needed and the type, timing, location, and duration of such therapy. Long-term primary care and specialist (physiatrist or neurology) follow-up should be arranged to identify patients with residual impairments so that these patients receive appropriate continued rehabilitation.
10. A stroke system should periodically assess its level of available rehabilitation services and community resources.
11. Efforts should be made to advance the use of technology and patient-reported outcomes and to facilitate improved care transitions in stroke care. These interventions

should be refined on the basis of continuous quality improvement measurement and methods. Such efforts not only will bolster overall stroke prevention, treatment, and recovery but also may reduce the persistent disparities observed in stroke care. Before implementation, new policies should be evaluated for potential adverse impact on access to care and disparities in care.

12. Federal or other governmental institutions should enact policies that standardize the organization of stroke care throughout the continuum. Such policies should aim to lower barriers to seeking emergency care for stroke, to ensure that stroke patients receive care at appropriate hospitals in a timely manner, and to facilitate access to secondary prevention and rehabilitation and recovery resources after stroke.

Conclusions

Since the AHA/ASA policy statement on stroke systems of care a decade ago,[1] major advances have occurred in the management of acute stroke, and the use of telemedicine technology has markedly reduced fragmentation of care, allowing stroke experts to be available to acute stroke patients wherever the patient is located. Programs geared at further improving the knowledge of the public, encouraging primordial and primary prevention, advancing and facilitating acute therapy, improving secondary prevention and recovery from stroke, and reducing disparities in stroke care should be actively developed in a coordinated and collaborative fashion by providers and policymakers at the local, state, and national levels. Such efforts will continue to mitigate the effects of stroke on society.

Disclosures

Writing Group Disclosures

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*Modest.

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*Modest.

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