Doi: 10.32481/djph.2023.08.005

Stroke Systems of Care:

A Systematic Approach to Saving Neurons

Kim Gannon, MD, PhD, FAHA

ChristianaCare Neurosciences

The author wishes to give special thanks to Ron Brown BS, NRP, Account Executive - Air Methods; Paul Westlake, Public Health Treatment Program Administrator and Systems of Care Coordinator; and John Roussis, MBA,CMTE, NRP, FP-C, Director of Pre-Hospital Services CareNet/LifeNet/ Transfer Center/ Mobile Integrated Health Paramedics for their assistance with State data collection and fact checking.

Abstract

Stroke continues to be a major public health concern, accounting for more than 800,000 strokes per year and remains the leading cause of disability. Stroke systems of care are comprehensive frameworks designed to ensure efficient and effective management of stroke patients. This article provides a brief overview of the coordinated network of healthcare providers, emergency medical services, and hospitals working together to deliver timely and specialized care including pre-hospital care, acute hospital care, rehabilitation, and community reintegration.

Introduction

Stroke continues to be the 5th leading cause of death and the leading cause of disability in the United States. This burden is significant – one stroke every 40 seconds in the United States, and one death from stroke every four minutes, totaling about 800,000 initial or recurrent strokes per year. The total cost of stroke is estimated to climb to $143 BILLION by 2035. Not only does this burden of stroke affect the individual, but also the family and care providers for this individual.[1] While interventions for detection and treatment of stroke have improved significantly over the past decade, systems of care surrounding stroke patients have improved identification and access to the right treatment at the right time. The American Stroke Association (ASA) first published recommendation in 2005 for the establishment of systems of care for stroke, followed by expansion in 2013 and updates in 2019.[2] Improving systems of care and improving access to care improves outcomes and prolongs healthy lives. Standards and systems impact outcomes – the American Heart Association's (AHA) "Get with the Guidelines" led to an 8% reduction in mortality and improved functional outcome at discharge.[3]

Key stakeholders in stroke systems of care consist of roles in the pre-hospital, acute care, and post-hospital setting including rehabilitation centers as well as primary care and ambulatory neurology. Acute care healthcare providers include physicians representing the emergency department, vascular and general neurology, neurointerventional surgery, neurosurgery, neuroradiology, and hospitalists. The acute care team also relies on highly qualified nurses, pharmacists, therapists, and stroke center coordinators. Post discharge coordination relies on acute and subacute rehabilitation, physiatry and therapy teams along with social workers to ensure continued care. Coordination and collaboration of these teams are essential to ensure optimal care.

The AHA and the Centers for Disease Control and Prevention (CDC) have published recommendations for establishing systems of care for optimal stroke management that include

Doi: 10.32481/djph.2023.08.005

legislation, prehospital care, inter-facility transfer, and acute hospital care, as well as post-hospital discharge.

Role of State Legislation

Delaware passed state legislation establishing the State Stroke Committee and the State System of Care in 2016. This collaboration represents ongoing work across our state including all non-government hospital systems. The Delaware State Stroke Committee represents the Joint Commission designated Comprehensive Stroke Center at ChristianaCare - Newark, and Primary Stroke Centers at Bayhealth Kent Campus, Bayhealth Sussex Campus, Beebe Healthcare, ChristianaCare - Wilmington Hospital, Saint Francis Healthcare, and Tidal Health – Nanticoke. State laws that support stroke systems of care can facilitate stroke care by providing a framework for collaboration and standardization of best practices.

A key aspect of stroke systems of care is continuous quality improvement, including tracking outcomes and identifying areas for improvement in stroke care delivery. State registries are used to collect data on stroke patients, track outcomes, and identify areas where care can be improved. This information is used to standardize best practices and ensure adherence to established standards of care. Shared learnings and adhering to standards of care reduces mortality rates, minimizes long-term disability, and improves quality of life for stroke survivors.[3,4] The Delaware State Stroke Committee meets regularly for continuous quality improvement review and standardization.

Pre-Hospital Care

Prehospital care is essential for identification and urgent routing of patients, relying on emergency medical services and flight center coordination of care, along with transportation and safety authorities. The prehospital care starts at the location of the patient – in the community. The AHA has worked to inform the public of signs and symptoms of acute stroke using the acronym "FAST," which stands for "Facial weakness," "Arm drift or weakness," "Speech abnormality," and "Time to call 911."[4] This quick and easy to remember acronym summarizes some of the major symptoms associated with stroke. Despite the efforts, more work needs to be done regarding public education and the importance of immediately seeking care for any symptoms of acute stroke. Optimal care for stroke must be accurate and speedy – after all, time is brain!

The Delaware State Stroke Committee has developed policy for standards of care for stroke in the state, including working with legislation to ensure systematic routing policies. Over the past year, the team has revised the recommended systematic approach to the stroke evaluation by the Emergency Medical Services (EMS) teams prehospital. The VAN score, which quickly assess **V**ision, **A**phasia, and **N**eglect, has been adopted for quick field assessment of stroke symptoms concerning for large vessel occlusion.[5] The EMS team communicates directly with emergency physicians at the nearest emergency department who guide routing to the nearest appropriate facility based on the symptoms that the patient is experiencing. When appropriate, the EMS team can call for air support directly to the scene – significantly improving outcomes, specifically for patients who have symptoms of a large vessel occlusion. Helicopter transport has improved transport capabilities and significantly decreased time from EMS patient retrieval to treatment at the correct facility, especially for more rural locations.[6] An alternative to air transport is Mobile Stroke Units (MSU) – ambulances with a CT scanner and ability to administer IV thrombolytics.

Doi: 10.32481/djph.2023.08.005

MSUs have been changing the landscape of stroke care since 2008.[7,8] This type of specialized ambulance originated in Germany with a goal of bringing stroke care to the patient – improving thrombolysis times and overall improving stroke outcome. Over the next decade, MSUs have expanded to over 25 sites around the world. The rig not only includes CT scanner technology, but also has the ability to perform point-of-care lab tests, routine medications, and IV thrombolytics (Alteplase/tPA or Tenecteplase/TNK), and is staffed by EMS personnel, a radiology technician, a nurse, and a neurologist – either on board or available via telemedicine.[9] While Delaware does not currently have a Mobile Stroke Unit, this could be an opportunity to improve care for patients that are far from a stroke center.

The overall goal of pre-hospital and acute stroke care is to decrease the time between stroke onset to stroke treatment, which can be accomplished by decreasing the time between symptom identification and EMS activation, or EMS activation and medical treatment. While the MSU takes the hospital to the patient, other technologies can be used to improve the readiness of the hospital to receive the patient, thus speeding up decision making abilities once the patient arrives to the Emergency Department (ED). Sussex and Kent County EMS teams have adopted a prehospital communication technology, Twiage®, to alert accepting hospitals of pertinent information prior to hospital arrival. New Castle County has started using Twiage® for cardiac events and is planning to implement this technology for stroke care. This pre-hospital alert notification has been a game-changer in the ability of the acute hospital team to be prepared for the patient with the right team and tools in place to treat the patient emergently. Pre-hospital notification allows the ED team to alert the Stroke Neurology team before the patient arrives and allows time to review medications and any other past medical history stored in the electronic medical record that would impact patient treatment. By having this information prior to the patient's arrival, systems of care have been able to reduce the door to treatment time by 18 minutes, and ensure that IV thrombolytics are not given to patients with contraindications. Every minute delay causes 12 million brain cells to die – prehospital notification is estimated to save more than 225 million brain cells for each patient![10]

Interfacility Transfer

Interfacility transfer is a crucial aspect of stroke care as it allows patients to receive specialized treatment and rehabilitation services that may not be available at their local hospital. Since 2019, the ChristianaCare LifeNet Air Medical team has placed an "EZ button" in the ED of many Delaware hospitals. This quick access technology notifies ChristianaCare LifeNet's Air Medical Dispatch Center to place a helicopter resource on standby. The Air Medical Dispatch team starts to source a helicopter to transfer to the scene of the pressed button even before the clinician speaks to an accepting hospital. This has substantially decreased the time required to source transit for the patient. While the clinician's attention is on the patient, the air command team is working to provide transit capabilities. This rapid access to interfacility transport significantly decreases delays in care. ChristianaCare LifeNet Air Medical has provided 215 flights for Neurologic care over the past 12 months, with 115 of these resulting from activation of the EZ button. This link in the State System of Care has significantly reduced not only the "door in, door out" time, but also improved the speed of interfacility transfer overall for our state.

However, transfer can also be associated with increased costs, longer hospital stays, and decreased quality of life for patients and their families. To minimize the negative effects of interfacility transfer, a triage system can be implemented to keep patients as close to home as

safely possible. This system involves evaluation of the patient's medical history, physical condition, and current symptoms to determine the appropriate level of care. Patients with mild to moderate strokes could receive treatment at their local hospital, while those with more severe strokes or who need surgical intervention may require transfer to a higher level of care. Determining which patients will benefit prior to transfer can facilitate keeping patients at their home institution.[3,4] Developing telemedicine programs, providing community-based rehabilitation services, and educating healthcare providers on the latest stroke care guidelines can also facilitate keeping patients at their local healthcare facilities. Delaware has implemented these strategies so that stroke patients can receive timely and appropriate care while minimizing the negative effects of interfacility transfer.

Acute Hospital Care

The ED plays a critical role in acute stroke care, with protocols designed to ensure rapid triage and timely interventions. Decreasing goal times for each step of acute stroke care – including door to triage, triage to imaging, imaging to interpretation, and interpretation to intervention – all work to reduce the time between symptom onset and definitive treatment. Team members involved in ED acute stroke care include nursing, physicians, pharmacy, clerks/registration team, CT techs, radiology, and others - each vital link in this sequenced chain of events helps to ensure efficient and effective care.[11] To decrease door to needle time, small things like delaying lab draws or using blood drawn by EMS, delaying EKG, not changing the patient into a gown, and removing jewelry prior to imaging can all work to improve treatment times. Access to artificial intelligence (AI) enabled imaging, such as RAPID AI®, allows for more expeditious treatment of patients. Not only does this type of technology reduce time to treatment and improve outcomes, but also allows for streamlined communications across systems to allow for more expeditious transfer.[12] Many Delaware hospitals are using RAPID AI® technology for image review. Utilization of this technology allows for expeditious review of images and decision making for transfer to a higher level of care for emergent intervention. Using imaging tools empowers physicians to make faster more accurate decisions for treatment.

ED treatment of patients with stroke has been revolutionized over the past decade by the increase in telemedicine. Even pre-COVID, stroke care was being provided by telemedicine. Telemedicine allows the neurologist with stroke expertise to be virtually present at bedside nearly immediately in the ED. Prior to the utilization of telemedicine, physicians relied on a reported examination by a physician who may or may not have expertise in the neurologic examination. By personally visualizing the patient, the neurologist can ask questions, go with the patient to CT and review any changing examination findings. This continued virtual presence allows for ongoing rapid decision making and communication with the nursing team at bedside. Telemedicine is one more way that Neurology has leaned on technology to expedite acute stroke care.[4]

Choice of medication has impacted the speed of interfacility transfer, as well as door to needle times. Recent data has supported transition from Alteplase (tPA) to Tenecteplase (TNK) for IV lytic management of acute ischemic stroke. This transition facilitates improved times for interfacility transfer given the one dose medication for TNK compared to the infusion “drip and ship” model required by tPA.[13] In the past two years, substantial data has developed safety standards for IV thrombolytic therapy; not only is TNK easier to use with equitable, if not superior safety data, but it is also cheaper to dose. The medication itself is about $2000 less

costly, but also does not require additional utilization of tubing, IV Saline and an IV pump.[13] The movement to TNK has been a game changer for systems across the State of Delaware.

Post-Hospital Care

Post-hospital follow up is just as important in the stroke system of care as inpatient care. It has been suggested that patients are brought into the hospital in a Ferrari but sent out with a parachute – alluding to the lack of outpatient follow up and support available to patients post-stroke. After optimal hospital treatment, many stroke patients are discharged to acute or subacute rehabilitation. It is incumbent on the discharging facility to provide the appropriate information to continue optimal care while in the rehabilitation facility. Ambulatory follow up with neurology is sometimes part of the patient's care plan, especially if the etiology of stroke remains unknown. However, there are some settings in which follow up with a stroke neurologist is not needed – specifically if the etiology of stroke is known.

Other providers are key in post-stroke care outside of neurology. Primary care physicians and advanced practice providers are instrumental in the Stroke System of Care by encouraging patients to continue secondary prevention of stroke, including medications, management of comorbidities, and lifestyle modification. Physical medicine and rehab / physiatry specialists are key to a patient's rehabilitation journey. The expertise they provide assists patients on the road to recovery and enables them to achieve mobility post-stroke. Psychiatry and psychology can also play a key role in helping patients recover from stroke. The psychologic challenges faced by patients and family can be better met with support from specialists. Many stroke patients face depression during their recovery – this is especially prevalent in the population of young stroke patients. The overall goal of post-stroke care is prevention of recurrent stroke and recurrent need for hospitalization, and the return of a patient to as near their prior baseline as possible.

Conclusion

Implementation of a Stroke System of Care establishes a systematic approach to stroke and enables our teams to work together for the best outcomes of the patient. Together, we work to decrease the time from symptom onset to treatment by utilizing community education, EMS partnerships, technology implementation and acute hospital care. We work to provide the right care in the right location at the right time, and provide expeditious transfer when required. Delaware Stroke System of Care provides access to the highest quality treatment and recovery options and is committed to continued excellence in the future.

Dr. Gannon may be contacted at kim.p.gannon@christianacare.org.

References

1. Gorelick, P. B., Furie, K. L., Iadecola, C., Smith, E. E., Waddy, S. P., Lloyd-Jones, D. M., ... Zerna, C., & the American Heart Association/American Stroke Association. (2017, October). Defining optimal brain health in adults: A presidential advisory from the American Heart Association/American Stroke Association. *Stroke, 48*(10), e284–e303. https://doi.org/10.1161/STR.0000000000000148 PubMed
2. Adeoye, O., Nyström, K. V., Yavagal, D. R., Luciano, J., Nogueira, R. G., Zorowitz, R. D., . . . Jauch, E. C. (2019, July). Recommendations for the establishment of stroke systems of

care: A 2019 update. *Stroke*, *50*(7), e187–e210. https://doi.org/10.1161/STR.0000000000000173 PubMed

3. Centers for Disease Control and Prevention. (2021, Jul). Stroke systems of care: Framework resources. https://www.cdc.gov/dhdsp/programs/framework_resources.htm
4. Centers for Disease Control and Prevention. (2018). *What is the evidence for state laws to enhance in-hospital and post-hospital stroke care? A policy evidence assessment report.* Atlanta, GA: Centers for Disease Control and Prevention. https://www.cdc.gov/dhdsp/pubs/docs/Pre-Hospital_Post-Hospital_Stroke_PEAR-508.pdf
5. Birnbaum, L., Wampler, D., Shadman, A., de Leonni Stanonik, M., Patterson, M., Kidd, E., . . . Miramontes, D. (2021, June). Paramedic utilization of Vision, Aphasia, Neglect (VAN) stroke severity scale in the prehospital setting predicts emergent large vessel occlusion stroke. *Journal of Neurointerventional Surgery*, *13*(6), 505–508. https://doi.org/10.1136/neurintsurg-2020-016054 PubMed
6. Jauch, E. C., Schwamm, L. H., Panagos, P. D., Barbazzeni, J., Dickson, R., Dunne, R., ... Yallapragada, A., & the Prehospital Stroke System of Care Consensus Conference. (2021, May). Recommendations for Regional Stroke Destination Plans in Rural, Suburban, and Urban Communities From the Prehospital Stroke System of Care Consensus Conference: A Consensus Statement From the American Academy of Neurology, American Heart Association/American Stroke Association, American Society of Neuroradiology, National Association of EMS Physicians, National Association of State EMS Officials, Society of NeuroInterventional Surgery, and Society of Vascular and Interventional Neurology: Endorsed by the Neurocritical Care Society. *Stroke, 52*(5), e133–e152. https://doi.org/10.1161/STROKEAHA.120.033228 PubMed
7. Fassbender, K., Merzou, F., Lesmeister, M., Walter, S., Grunwald, I. Q., Ragoschke-Schumm, A., . . . Grotta, J. (2021, May 25). Impact of mobile stroke units. *Journal of Neurology, Neurosurgery, and Psychiatry*, *92*(8), 815–822. https://doi.org/10.1136/jnnp-2020-324005 PubMed
8. Harris, J. (2021, September). A review of mobile stroke units. *Journal of Neurology*, *268*(9), 3180–3184. https://doi.org/10.1007/s00415-020-09910-4 PubMed
9. Navi, B. B., Audebert, H. J., Alexandrov, A. W., Cadilhac, D. A., & Grotta, J. C., & the PRESTO. (Prehospital Stroke Treatment Organization) Writing Group. (2022, June). Mobile stroke units: Evidence, gaps, and next steps. *Stroke, 53*(6), 2103–2113. https://doi.org/10.1161/STROKEAHA.121.037376 PubMed
10. Kim, S. K., Lee, S. Y., Bae, H. J., Lee, Y. S., Kim, S. Y., Kang, M. J., & Cha, J. K. (2009, December). Pre-hospital notification reduced the door-to-needle time for iv t-PA in acute ischaemic stroke. *European Journal of Neurology*, *16*(12), 1331–1335. https://doi.org/10.1111/j.1468-1331.2009.02762.x PubMed
11. Powers, W. J., Rabinstein, A. A., Ackerson, T., Adeoye, O. M., Bambakidis, N. C., Becker, K., . . . Tirschwell, D. L. (2019, December). Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*, *50*(12), e344–e418. https://doi.org/10.1161/STR.0000000000000211 PubMed

Doi: 10.32481/djph.2023.08.005

12. Cirio, J. J., Ciardi, C., Buezas, M., Diluca, P., Caballero, M. L., Lopez, M., . . . Lylyk, P. (2021). Implementation of artificial intelligence in hyperacute arterial reperfusion treatment in a comprehensive stroke center. *Neurol Argentina, 13*(4), 212–220. https://doi.org/10.1016/j.neuarg.2021.07.003

13. Warach, S. J., Dula, A. N., Milling, T. J., Miller, S., Allen, L., Zuck, N. D., . . . Paydarfar, D. (2022, December). Prospective observational cohort study of tenecteplase versus alteplase in routine clinical practice. *Stroke*, *53*(12), 3583–3593. https://doi.org/10.1161/STROKEAHA.122.038950 PubMed