Official Journal of the Association of Neurovascular Clinicians

STROKE CLINICIAN

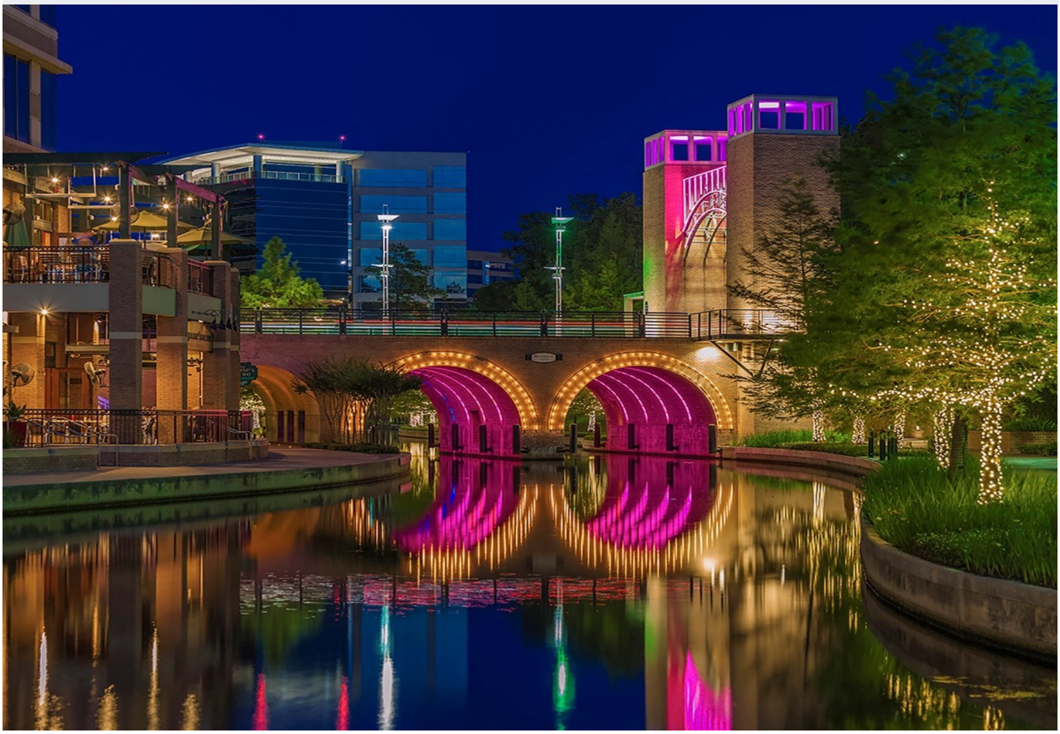
Volume 1, Number 2, April-June 2024
StrokeClinician.org

CALL FOR 2024 ANVC CONFERENCE ABSTRACT SUBMISSIONS

The ANVC Annual Conference is the perfect venue to share your original science and quality improvement findings with your peers. We welcome submissions that share methods to improve stroke systems of care, important clinical interventions and findings that improve patient outcomes, and innovative strategies to better develop stroke team members.

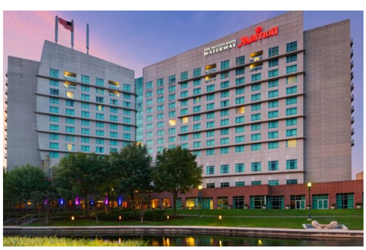
Instructions for submission can be found at www.anvc.org

Submission deadline: August 31, 2024.



LOCATION

The Woodlands Waterway
Marriott Hotel & Convention Center
1601 Lake Robbins Drive
The Woodlands, Texas, USA, 77380



Registration for the 2024 ANVC Annual Conference is NOW OPEN!
Register Today at www.anvc.org

WANTED:
CLOTS & COFFEE PHOTOS

Did your team participate in Clots & Coffee?
Please send your photos, along with the name of your hospital/stroke team to info@anvc.org by June 30th for a special photo collage celebration in the upcoming issue of Stroke Clinician.

Official Journal of the Association of Neurovascular Clinicians

STROKE CLINICIAN

Stroke Clinician: Table of Contents: Full Issue

Association of Neurovascular Clinicians
16410 E. Emerald Drive Suite 201
Fountain Hills, AZ 85268
info@anvc.org

Official Journal of the Association of Neurovascular Clinicians
STROKE CLINICIAN

Stroke Clinician: Table of Contents: Full Issue (continued)

ANVC is excited to announce its official journal, Stroke Clinician! The Journal is focused exclusively on publication of clinically relevant papers that cover all aspects of neurovascular disease practice and are of interest primarily to non-physician clinicians and stroke administrators. Relevant content should focus on any of the following subject areas:

- Primary or secondary stroke prevention topics
- Stroke emergency management
- Innovative strategies for organizing stroke care or stroke programs
- Acute diagnosis and interprofessional management topics in patients with ischemic or hemorrhagic stroke including neurocritical care of stroke patients
- Complication avoidance and complication management in stroke patients
- Transitions in stroke care across the continuum
- Stroke center certification preparation
- Stroke program quality improvement projects
- Educational preparation of stroke clinicians and/or stroke patients
- Stroke practice protocols and methods to standardize practice
- Innovative stroke unit organization and structure

We are currently accepting submissions at [Information For Authors | Stroke Clinician (psu.edu)]

Association of Neurovascular Clinicians
16410 E. Emerald Drive Suite 201
Fountain Hills, AZ 85268
info@anvc.org

Message from the Editor-in-Chief

Evidenced-Based Practice: From NIHSS Updates, to Stroke Navigation, Blood Pressure Measurement, and Educational Best Practices

Anne W. Alexandrov, PhD, AGACNP-BC, ANVP-BC, ASC-BC, CCRN, FAAN

This issue of *Stroke Clinician* provides exciting information to better our care of vulnerable neurovascular patients. First, in our ANVC President's Column, Alicia Richardson discusses the National Institutes of Health Stroke Scale (NIHSS), describing limitations and strengths, and providing us with new information about updates to the pictures used in assessment of NIHSS item 9, *Best Language*. Please consider downloading the new pictures available for free through the NIH's National Institute of Neurological Disorders and Stroke website.[1]

We then move into the dynamic realm of stroke navigation, starting with an important guest editorial provided by Jennifer Edwards, a national leader in patient navigation who has played a key role in this process for many different chronic and complex patient illnesses. Jennifer provides us with context to the navigation process that makes clear what should be happening to support highly vulnerable patients, including stroke. Following Jennifer's editorial are 3 important original articles detailing navigation role delineation, implementation, and outcomes in different settings across the United States. What clearly stands out is the fact that no two programs are alike. Some navigation programs are utilizing stroke nurses in the navigator role, others use social workers, and even occupational therapists; the depth of the role and the services offered also vary considerably, with some continuing to evolve, others well-established, and one providing contract services to hospitals unable to provide their own navigation programs. Comparing stroke navigation to the well-defined services Jennifer Edwards describes for oncology provides an ability to conduct a gap analysis of where we are now, and where we need to go in the future. These key articles are important editions to your stroke center libraries as you consider navigator implementation. Dr. Sarah Livesay's and Debbie Hill's Stroke Center Corner contribution further complements the

Message from the Editor-in-Chief

navigation articles in this issue and provides a wonderful overview of ways that leading stroke centers are expanding their services and their reach to patients after discharge.

Many interprofessional stroke clinicians take measurement of blood pressure for granted, often paying little attention to how values are obtained. Sadly, this results in values that are often erroneous, yet many clinicians fail to recognize this. Dr. Desiree Cihelka provides a detailed review of evidence-based blood pressure measurement methods, including an interesting history of how measurement methods have evolved into how we should be measuring blood pressure today. ANVC has included a very brief overview of this information within its NVRN, ASC, and ANVP courses for years, but Dr. Cihelka takes this to a whole new level by providing data that clearly draw into question the internal validity of most of the blood pressure research that supports how we care for stroke patients today. I encourage you to use this review article for a Stroke Journal Club event at your hospital. With the American Heart Association recently finding that most physicians and nurses today fail to utilize correct measurement techniques in practice, clearly all of us could benefit from reading this paper and discussing it with our interprofessional peers.

Lastly, Linda Sugrue's original paper presents us with information on how to effectively educate our interprofessional clinical stroke colleagues on key core metrics. Her highly innovative BRAVEST tool provides an implementation-ready process for use in all stroke certified hospitals, facilitating essential Stroke Team care processes through patient huddle discussions, name tag attachments, and more.

All our other standing columns are included as always in this issue of *Stroke Clinician*, including a Neuroimaging Case Review, Research Corner with a look at the Canadian AcT clinical trial,[2] to test items in our Certification Corner, and a look at the Royal University Hospital's specialized stroke unit in Saskatoon, Saskatchewan within our column titled, *In Our Stroke Unit*. We hope you will be interested in proudly sharing your specialized stroke unit with our *Stroke Clinician*'s readers in a future issue; to do so, please submit descriptive content and photos using our journal submission portal at: https://journals.psu.edu/strokeclinician.

We think you'll agree that this issue of *Stroke Clinician* is jam-packed with evidence-based, highly clinically relevant reading to support professional growth for both you and your colleagues. After all, "stroke patients deserve nothing less!"

References

1. National Institutes of Neurological Disorders and Stroke. NIH Stroke Scale Updated with New Visual Stimuli | National Institute of Neurological Disorders and Stroke Accessed May 5, 2024.
2. Menon BK, Buck BH, Singh N, et al.; AcT Trial Investigators. Intravenous tenecteplase compared with alteplase for acute ischaemic stroke in Canada (AcT): a pragmatic, multicentre, open-label, registry-linked, randomised, controlled, non-inferiority trial. Lancet. 2022 Jul 16;400(10347):161-169. doi: 10.1016/S0140-6736(22)01054-6. Epub 2022 Jun 29. PMID: 35779553.

ANVC President's Message

NIHSS: Is It Time For A Change?

Alicia Richardson, MSN, ACCNS-AG, ANVP-BC, ASC-BC

The National Institute of Health Stroke Scale (NIHSS) was introduced over 30 years ago[1] and is the stroke assessment tool most widely used across the world in acute care hospitals. The NIHSS was originally designed for use in clinical trials so that initial stroke deficits and changes in the clinical exam could be quantified. The developers never foresaw the NIHSS as something that would be used routinely in clinical care to assess stroke patients, although today it is standard of care. Similarly, the Glasgow Coma Scale (GCS) is another example of a tool that was not created for ongoing patient assessment; but unlike the NIHSS which was designed for repeat assessments, the GCS was originally intended as a tool to be used only once to prognosticate outcome from traumatic brain injury.[2]

There are several advantages to use of the NIHSS in clinical practice that should be acknowledged, namely the tool is valid as a measure of neurologic deficits in both acute ischemic stroke[1] and also intracerebral hemorrhage;[3] it is also reliable making findings reproducible across providers.[4] The NIHSS can also predict the volume of a brain infarct,[5] stroke severity,[1] and outcome.[6] However, there are also disadvantages and imperfections associated with the NIHSS, and clinicians should be aware of these limitations. Stroke Clinicians certainly recognize the complexity of stroke symptoms, making creation of one perfect tool that is capable of meeting the needs of all types of stroke challenging.

Some notable limitations of the NIHSS are significant differences in scores for right versus left brain stroke and anterior circulation versus posterior circulation stroke,[6] clinician confusion over management of an NIHSS of 0, the "ceiling effect," the time it takes to perform the assessments, confusion over scoring of ataxia, and subjectivity of components like dysarthria and facial droop.[7]

Differences in the score of right versus left hemispheric stroke patients were first identified by Woo and colleagues in 1990.[6] Because the NIHSS has a total of 7 possible points tied to language (items 1B, 1C, and 9), patients with left-hemispheric stroke commonly carry higher NIHSS scores than those with right-hemispheric stroke, since neglect (a right hemispheric function; item 11) carries only a maximum of 2 points. Consequently, right hemisphere strokes may be less likely to receive thrombolysis than left sided stroke counterparts.[7] Posterior circulation stroke symptoms are also not well captured by the NIHSS, in fact many posterior strokes score very low or not at all on the NIHSS, with more than 75% having an initial score between 0 to 5 points.[7] This leads to the next limitation: NIHSS scores of 0 are often misinterpreted as absence of a stroke or insufficient neurologic deficits to warrant treatment. Since the NIHSS is not all encompassing, further evaluation must occur to determine what additional assessments may be necessary, along with determination of whether the stroke symptoms are disabling.[8] Stroke symptoms like headache, dizziness, dominant hand weakness, dysphagia, and ataxic gait would all score an NIHSS of 0, yet most all stroke patients would consider these symptoms disabling.

Ceiling effect refers to using maximum scores to reflect items that cannot be tested easily in unresponsive or comatose patients; this makes the NIHSS less clinically relevant.[7] The length of the NIHSS has also been criticized as being too time consuming to complete if following the original instructions. Clinicians often make their own adjustments or remove testing of items on the scale to speed up the assessment process, but these changes challenge both the interrater reliability and the validity of the tool.[9] While the NIHSS overall has been found to be reliable, components of the tool remain more subjective or prone to increased examiner error. Items like interpretation of extraocular movements, dysarthria, and facial palsy have poorer reliability than other components of the scale.[7] Examiner errors also tend to occur in items like level of consciousness, visual fields, neglect, and ataxia in relation to underlying motor weakness.

Lastly, the picture cards used for testing language fluency have been heavily criticized.[10] These pictures were initially developed exclusively for an English-speaking, Western population and therefore do not translate well across other cultures. Additionally, the picture of the woman in the kitchen washing the dishes has perpetuated former stereotypical gender roles. Recently, these pictures were updated to include a more culturally appropriate scenario, along with updated objects to name.[10] The new picture cards have been validated and are available on the NINDS website (Figure 1). Literacy concerns are also tied to the NIHSS phrases, as not all patients can read these, including those without disabilities or stroke.[10]

Several iterations of the NIHSS have been proposed through the years to address these pitfalls. Introduced in 2002, the modified NIHSS (mNIHSS) focused on reducing redundancy and eliminating items with poor reliability,[11] however the mNIHSS has not been widely adopted because of poor detection of posterior stroke symptoms. Later, the shortened NIHSS (sNIHSS) was introduced, but despite multiple slim versions, these scales commonly fail to detect disabling stroke symptoms, especially in the setting of minor stroke and are not recommended.[9] The POST-NIHSS was introduced in 2021 as a measure capable of improving capture of posterior stroke symptoms.[12] The added items on the POST-NIHSS include assessments for ataxic gait and bulbar symptoms such as abnormal cough and dysphagia, and these are weighed higher so that patients with posterior circulation strokes would not be considered "mild" due to a low overall score.[12] The POST-NIHSS also has not been widely adopted, in large part due to the added length of the tool.

While some stroke clinicians believe it is time for a change from the NIHSS, until a tool is developed that prioritizes efficiency yet does not compromise the ability to diagnose all types of stroke, the NIHSS – despite its shortcomings – will continue to be utilized. Development of valid and reliable instruments is not a simple undertaking, typically requiring years of rigorous research. At this point in time arguably, the NIHSS remains the best instrument available to capture stroke disability.

Figure 1: Updated NIH Stroke Scale pictures; available for download from [NIH Stroke Scale Updated with New Visual Stimuli | National Institute of Neurological Disorders and Stroke](#).

References

1. Brott T, Adams HP, Olinger CP, Marler JR, Barsan WG, Biller J, Spilker J, Holleran R, Eberle R, Hertzberg V. Measurements of acute cerebral infarction: a clinical examination scale. *Stroke***.** 1989; 20:864–870. doi: 10.1161/01.str.20.7.864
2. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. *Lancet* 1974,2:81-84.
3. Dusenbury W, Tsivgoulis G, Chang J, Goyal N, Swatzell V, Alexandrov AV, Lyden P, Alexandrov AW. Validation of the National Institutes of Health Stroke Scale in intracerebral hemorrhage. *Stroke: Vascular and Interventional Neurology*. 2023;3(4): e000834. https://doi.org/10.1161/SVIN.123.000834.
4. Dewey HM, Donnan GA, Freeman EJ, Sharples CM, Macdonell RA, McNeil JJ, Thrift AG. Interrater reliability of the National Institutes of Health Stroke Scale: rating by neurologists and nurses in a community-based stroke incidence study. *Cerebrovasc Dis***.** 1999; 9:323–327. doi: 10.1159/000016006Volume of infarct paper
5. Sato S, Toyoda K, Uehara T, Toratani N, Yokota C, Moriwaki H, Naritomi H, Minematsu K. Baseline NIH Stroke Scale Score predicting outcome in anterior and posterior circulation strokes. *Neurology*. 2008; 70(24 pt 2):2371–2377. doi: 10.1212/01.wnl.0000304346.14354.0b
6. Woo D, Broderick JP, Kothari RU, Lu M, Brott T, Lyden PD, Marler JR,

Grotta JC. Does the NIHSS favor left hemisphere strokes? *Stroke*, 1999;30:2355-2359.

7. Makharia A, Agarwal A, Garg D, Vishnu V, & Srivastava P. (2023). The Pitfalls of the NIHSS: Time for a new clinical acute stroke severity scoring system in the emergency? *Annals of Indian Academy of Neurology*, DOI 10.4103/aian.aian_842_23
8. Martin-Schild S, Albright KC, Tanksley J, Pandav V, Jones EB, Grotta JC, et al. Zero on the NIHSS does not equal the absence of stroke. *Ann Emerg Med* 2011;57:42–5.
9. Nye B, Hyde C, Tsivgoulis G, Albright K, Alexandrov AV, Alexandrov AW. (2012). Slim stroke scales for assessing patients with acute stroke: Ease of use or loss of valuable assessment data? *Am J Crit Care, 21,* 6, 442-448. DOI 10.4037%2Fajcc2012633
10. Stockbridge M, Kelly L, Newman-Norlund S, White B, Bourgeois M, Rothermel E, Fridriksson J, Lyden P, & Hillis A. (2024). New picture stimuli for the NIH Stroke Scale: A validation study. *Stroke 55*, 443-451, DOI 10.1161/STROKEAHA.123.044384
11. Meyer B, Hemmen T, Jackson C, & Lyden P. (2002). Modified National Institutes of Health Stroke Scale for Use in Stroke Clinical Trials: Prospective Reliability and Validity. *Stroke*, *33,* 1261-1266, DOI 10.1161/01.STR.0000015625.87603.A7
12. Alemseged F, Rocco A, Arba F, Paulasova Schwabova J, Wu T, Cavicchia L, Felix N, Ng J, Williams C, Sallustio F, Balabanski A, Tomek A, Parson M, Mitchell P, Diomedi M, Yassi N, Churilov L, Davis S, & Campbell B. (2021). Posterior National Institutes of Health Stroke Scale Improves Prognostic Accuracy in Posterior Circulation Stroke. *Stroke*, 53, 1247-1255. DOI 10.1161/STROKEAHA.120.034019

Guest Editorial

Disease Navigation: From Oncology to Chronic and Complex Illness

Jennifer Edwards, BSN, RN, OCN, LSSGB[1,2]

"*Maybe we should navigate them*", said Dr. Harold Freeman of Harlem, New York in 1990 after participating in the *Report to the Nation on Cancer in the Poor,* produced by the American Cancer Society.[1] This statement gave birth to oncology patient navigation programs. As an experienced oncologist, Dr. Freeman witnessed firsthand how our complex health care systems challenge patients and family members with numerous barriers to care, including healthcare disparities and socioeconomic challenges. Combined, barriers to care and difficulty navigating the healthcare system delay both diagnosis and treatments, negatively impacting the lives of patients with cancer and chronic disease.

Dr. Freeman set forth to improve early detection of cancer through access, while working to make healthcare easier to receive despite socioeconomic status. He started the first patient navigator program where community members were taught the gold standard of navigation: Decreasing time to diagnosis through the removal of barriers and providing support to patients across the complex healthcare continuum. Based on Dr. Freeman's work, the Patient Navigation Act was passed in 1995, bringing more attention to the importance of navigation as a lifesaving process. Later, the Harold P. Freeman Patient Navigation Institute opened, teaching best practices, standards, and the "Principles of Patient Navigation."[2]

Navigation principles define patient navigation as a patient-centric healthcare service delivery model that personalizes and integrates a fragmented healthcare system. Navigation should facilitate timely care by removing barriers, clarifying scope and roles within the healthcare team, and ensuring cost-effectiveness as possible. Navigators should be trained to support their patients' individualized needs and should utilize entry and exit criteria, becoming the "connection" for disconnected healthcare systems to ensure coordination of care.[3]

Early models of patient navigation utilized community health workers (CHW), non-licensed individuals trained on and supported by navigation concepts based on Freeman's principles. To meet the needs of a complex healthcare environment, patient navigation has grown to include many disciplines from trained lay persons to nursing, social work, and other disciplines. Patient navigation has also expanded to include sub-categories like financial navigator, resource navigator, community navigator, and care navigator.

An example of navigation's professional journey is the evolution of the Academy of Oncology Nurse Navigators (AONN). Founded in 2008 by Lillie Shockney, AONN set nurse navigation as a nursing specialty supported by a national organization. AONN developed and disseminated best practices, increased networking, provided education, and developed navigation metrics to quantify outcomes for these specialty nurses. AONN has since been renamed as the Academy of Oncology Nurse Navigators & Patient Navigators (AONN+) to include membership of patient navigators. AONN+ has continued to grow and support all oncology navigators through certification, local and national networking, and best practices supported by quality metrics based on the Oncology Navigation Standards.[4]

Whether cancer diagnosis or treatment, lingering post-cancer treatment symptoms, or patients with other complex or chronic diseases, healthcare systems and care requirements frequently necessitate coordination of numerous services to ensure timely care. Patient navigation is not only the standard of care for oncology patients, but it has also quickly become recognized as essential for many different diagnoses, including stroke as presented in this issue of the *Stroke Clinician*. After demonstrating success in improving patient outcomes, navigation services have expanded to include chronic and complex care specialties such as heart failure, addiction medicine, pulmonary hypertension, primary care, trauma, emergency medicine, and of course stroke.

While chronic and complex care navigators have been able to glean methods from the standards, metrics, and best practices framed by Dr. Freeman and oncology navigators, sub-specialized care needs are likely to differ substantially based on disease-type and co-morbidities making navigation roles look somewhat different by specialty. Additionally, work relationships may differ considerably, with navigators for chronic and complex illnesses working alongside a variety of different patient care teams instead of working within one specialty team such as oncology. Where oncology navigation has expanded to routinely include sub-navigation consisting of social workers, case managers, financial navigators, pharmacy advocates, and other nursing, medical and clinic staff, navigation for chronic and complex illnesses is slowly evolving to this degree of sophistication.

Today's stroke navigators are most commonly neurovascular educated and clinically trained professionals, often certified in the specialty. Optimally, stroke navigators should on-board patients while still in the hospital, working in concert with interprofessional specialty providers, and assessing for barriers including social determinants of health (SDOH) that may impact recovery and outcome. Stroke navigators provide personalized education and support, address specialty medication assistance needs, facilitate follow up appointments or testing, provide community resources, and become the key point of contact to advocate for the patient and family post-discharge. Classically, navigators maintain contact with patients through phone calls that occur at certain increments post-discharge. These calls assess how patients are managing post-hospitalization transitions, identify and remove barriers, and provide opportunities to support individualized needs. In some healthcare systems, stroke navigators also hold stroke survivor support groups and provide community outreach and education. Collectively, stroke navigator interventions have been associated with reductions in unplanned hospital readmissions and improved stroke survivor outcomes.[6]

Chronic and complex navigation continues to grow nationally in the USA. AONN+ founder Lillie Shockney has been consulted by numerous chronic and complex nurse navigator groups that aim to build and standardize their navigator roles to meet specialty patients' needs. Shockney's team conducted a national survey of navigator leaders, finding that chronic and complex nurse navigators needed an organization to bring them together to promote networking, identify and disseminate best practices, and to further growth of the navigator role. These findings fueled the launch of the Association of Chronic and Complex Care Nurse Navigators (ACCCNN) in 2021. ACCCNN's vision is, "*Innovate, elevate, and grow the role of the chronic and complex care nurse navigator*,"[7] and the organization's mission is to, "*Provide a platform that educates, supports, and empowers chronic and complex care nurse navigators to drive transformative patient-centered care*."[7] ACCCNN is a sister organization to AONN+ and was founded by Lillie Shockney, and co-founded/ co-led by Billie Lynn Allard and myself. ACCCNN's first National Summit was held in conjunction with AONN+ in 2023, where navigators and leaders presented on their programs, shared navigation stories, discussed opportunities for role improvement and growth, and celebrated winning role outcomes. Collectively, the Summit foretold a bright future for chronic and complex patient navigation. ACCCNN's second Summit will be held in November of 2024, and promises to continue building momentum within this growing specialty practice.

Navigation has made a major impact on healthcare, all stemming from Dr. Freeman's original comment, "*Maybe we should navigate them*." Support for patient navigation has grown substantially since 1990, and 2024 marks the *Year of Navigation*, with the Centers for Medicare and Medicaid launch of coding and payment rules for principle illness navigation. The navigation journey is only just the beginning!

Author Affiliations & Correspondence

Jennifer Edwards
RN Clinical Services Director
Banner Health
Banner University Hospital
1111 E. McDowell Rd.
Phoenix, AZ 85006[1]
Jennifer.Edwards9@bannerhealth.com
Co-Founder and Co-Program Director
Association of Chronic and Complex Nurse Navigators (ACCCNN.org)[2]

Guest Editorial

References

1. Harold Freeman, father of patient navigation, on cutting the cancer out of Harlem. Cancer History Project. Accessed March 21, 2024. https://cancerhistoryproject.com/people/harold-freeman-cutting-cancer-out-of-harlem/
2. Freeman HP, Rodriguez RL. History and principles of patient navigation. *Cancer*. 2011;117(S15):3537-3540. doi:10.1002/cncr.26262
3. Freeman HP. The origin, evolution, and principles of patient navigation. *Cancer Epidemiology, Biomarkers & Prevention*. 2012;21(10):1614-1617. doi:10.1158/1055-9965.epi-12-0982
4. Shockney LD, Allard BL, Dean M. Chronic Disease and Complex Care Navigators: A Scoping Review. *Journal of Oncology Navigation & Survivorship*. 2021;12(7). https://www.jons-online.com/issues/2021/july-2021-vol-12-no-7/3852-chronic-disease-and-complex-care-navigators-a-scoping-review.
5. White Paper. Association of Chronic & Complex Care Nurse Navigators. Accessed March 22, 2024. https://acccnn.org/white-paper.
6. Jun-O'Connell AH, Grigoriciuc E, Gulati A, et al. Stroke nurse navigator utilization reduces unplanned 30-day readmission in stroke patients treated with thrombolysis. *Frontiers in Neurology*. 2023;14. doi:10.3389/fneur.2023.1205487
7. Home. Association of Chronic & Complex Care Nurse Navigators. 2024. Accessed March 24, 2024. https://www.acccnn.org/.

Development and Implementation of a Stroke Nurse Navigator Position to Improve Program and Patient Outcomes

Leslie Pope, MSN, RN, ASC-BC,[1] Nicole Dellostretto, LPN,[1] Kelly Buchinsky, MSN, RN,[2] Patty Noah, MSN, RN, ASC-BC[1] Chris Hackett, MA,[1] Russell Cerejo, MD,[1] Ashis Tayal, MD[3]

Abstract

Background

Transitions in stroke care across the healthcare system are complex, requiring significant patient and family support. Navigation has been used in other disease states including oncology but has not been described well in the stroke population.

Methods

Our stroke program leadership performed a gap analysis to identify opportunities to streamline the care transition process. The emerging stroke nurse navigator role was implemented to meet patient/family needs and ensure implementation of evidence-based stroke services throughout transitions across the stroke system of care.

Results

The stroke navigator role was formally implemented in April 2018, along with adaptive patient selection criteria that have evolved as expertise in navigation has grown. Clarity in role function between the stroke coordinator and stroke navigator positions was established demonstrating the synergistic relationships between these two roles. Similarly, interventions and services performed routinely by stroke navigators developed over time as navigators became well versed in the needs of patients and families in the post-acute phase of care. We provide a detailed history of our 6-year experience with stroke navigation and make recommendations for role adoption and enactment.

Conclusion

Stroke navigator roles are likely to continue to grow to support the complex needs of stroke survivors and family members. Flexibility in role development and reflective role evolution are encouraged to support growth of the stroke navigator position and measures of role effectiveness.

Key words: Stroke navigator; care transitions; care navigation; care coordination; stroke care.

INTRODUCTION

Every year more than 795,000 people in the United States have a new or a recurrent stroke.[1] Despite advancements in treatment options, stroke remains a leading cause of disability. These advancements, along with the introduction of bundled payments and outcome-based incentives for organizations, have elevated stroke care in the acute phases of treatment; however, gaps in post-acute and transitions of care continue to exist.[2, 3] As a result, the need for provider collaboration and care coordination have risen to the forefront, necessitating the development of the stroke nurse navigator role.

The complexity of the healthcare system often leads patients to receive fragmented post-acute care. Navigation has the potential to eliminate barriers and assist patients as they journey through the care continuum.[4] While navigation has existed in fields such as oncology for decades, navigation of the stroke patient is a new and emerging role.[5]

Today, little information exists regarding the roles and responsibilities of the stroke nurse navigator, appropriate outcomes to measure, and effectiveness of the role. Hospital systems may be hesitant to fund a stroke navigator position because of this lack of information, and an undemonstrated return on investment. However, some organizations have been successful in securing funds through grants to support a navigator.[6] We recognized the potential value and impact this role could have on the community we serve and therefore our organization developed a stroke navigator program.

METHODS

Our organization is part of an integrated delivery network that provides patient care through several centers of excellence and advanced specialties. As part of the integrated delivery network, we continuously strive to provide high quality care while also containing cost for both the network and the consumer. Payor analyses identified that stroke carries high costs with each patient episode; therefore, we reviewed episodes for possible cost savings and opportunities to improve quality of care. Several quality improvement projects resulted in internal hospital cost reduction complemented by improved quality of care; however, we were unable to impact the cost of post-acute care, highlighting the need for improved care coordination.

An expert consensus panel was assembled consisting of the cerebrovascular medical director, administrative director of the stroke program, stroke coordinators, nursing directors, and a project manager to conduct a gap analysis. Several opportunities were identified to improve care transitions (Figure 1).

Qualitative data were collected from patients and their families reporting information overload, an unclear understanding of the discharge plan and/or medications, and an overall difficulty in navigating the complexities of the healthcare system. We also found that patients were transitioning to facilities delivering inadequate care due to knowledge deficits among the interprofessional staff. There was also a lack of communication between community health care providers such as home care staff, outpatient therapists, primary care physicians, other specialists, and stroke providers regarding patients' plans of care. As a result, the expert consensus panel

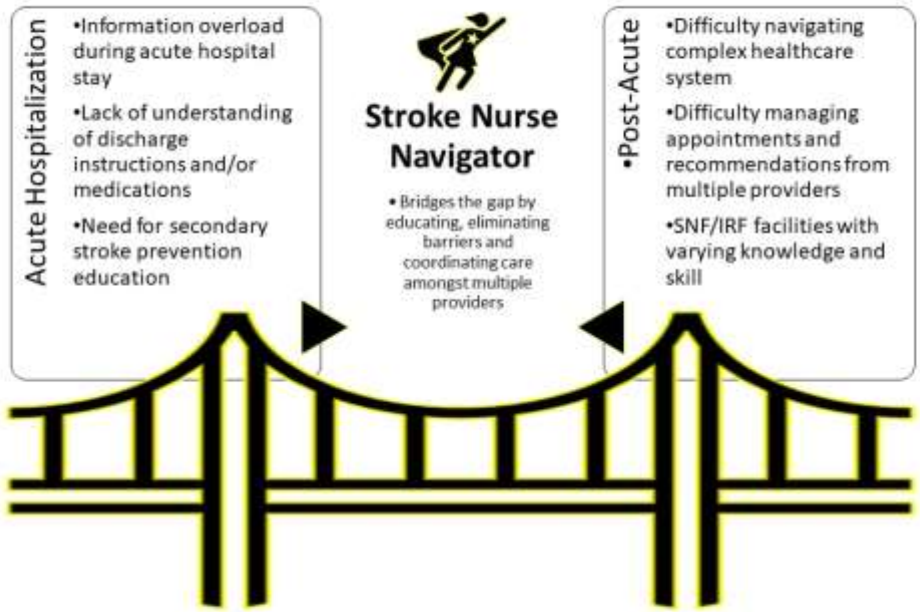


FIGURE 1: Bridging the Gap. Findings of expert panel gap analysis.

proposed a stroke nurse navigator role to bridge the gap between acute and post-acute levels of care, and to assist patients through the complex healthcare system. The stroke navigator position was presented and approved by senior leadership and funded by the integrated delivery network.

RESULTS

Implementation and Role Evolution

By April 2018, the role of stroke nurse navigator had been developed and implemented at our comprehensive stroke center. The expert consensus panel and the first navigator worked as a team to define patient selection criteria (Table 1).

The initial patient population was limited to a primary diagnosis of acute ischemic stroke. The team also set long-term program goals that included improvement in care coordination, decreased post-acute care episode costs, patient/family perceptions of an improved care experience, and improved patients' and families' understanding of the post-acute plan of care. The team did not explicitly define a process for achieving these goals at the time of program initiation, and instead promoted a culture of stroke navigation that allowed for role exploration to achieve these defined goals. By July of 2018, additional stroke nurse navigators were added in the network's primary stroke centers. This team of stroke nurse navigators were then tasked to utilize their clinical expertise and critical thinking skills to define the role, daily operations, and create tools within the electronic medical record to assist with program management and evaluation.

TABLE 1. INITIAL PATIENT SELECTION CRITERIA

Inclusion Criteria	**Exclusion Criteria**
Age ≥ 18 years	Age ≤ 18 years
Received Acute Stroke Therapy (IV Thrombolytics and/or Mechanical Thrombectomy)	Iatrogenic Stroke
Neurology clinical diagnosis of acute or subacute stroke	Cardiac Arrest during hospitalization
Positive imaging results (CT or MRI)	Hemorrhagic Stroke

Initially the stroke navigator role focused heavily on reducing readmissions, unplanned care, and reducing costs for patients discharged to an inpatient rehabilitation facility or a skilled nursing facility, as these were identified as high-cost episodes. Partnering with our integrated delivery network, thirteen facilities across Western Pennsylvania were identified as preferred facilities for our patients. An educational needs assessment was performed which identified that staff at these facilities had varying levels of knowledge and skill in the care of post stroke patients. The navigator team provided the staff at these facilities with comprehensive post-stroke care education in an attempt to standardize knowledge and care of patients admitted to these facilities (Table 2).

The team then identified point of contact persons for each of the facilities within both nursing and rehabilitation services. During the acute hospitalization, stroke nurse navigators met with patients and families and provided them with a list of preferred facilities and educated them on their role. When patients transitioned to a preferred facility, the navigator-initiated contact with the identified staff members and began weekly care conference calls. The purpose of these calls was to identify gaps in care delivery, discuss patient progress with therapy, and identify barriers to transitioning back to the community. All patients, regardless of discharge disposition, received a 90-day follow up phone call to obtain a modified Rankin scale score.

Management of patients in the preferred facilities proved to be challenging. The volume of patients transitioning to these facilities was less than anticipated. The weekly care conference calls were not beneficial because crucial information was not provided by staff, limiting the ability of the nurse navigator to assist with post-stroke care decisions. Despite ongoing educational efforts, high turnover within these facilities combined with lack of managerial control for staff performance impacted our ability to improve awareness of the stroke navigator role, as well as staff knowledge and engagement in stroke recovery. The onset of the COVID pandemic in March of 2020 further amplified these challenges.

The pandemic forced the stroke nurse navigator role to evolve into its current state. Navigators began working remotely and visitors were restricted from hospitals, eliminating the ability to meet patients and families during the acute hospitalization. The pandemic made transitioning to facilities more challenging partly because of limited bed capacity, coupled with an increase in the number of patients preferring to return home. As a result, the navigator team made a

TABLE 2. POST-ACUTE FACILITY STAFF EDUCATION

Educational Topic	Target Audience
Role of the Stroke nurse navigator	All Staff
Head to Toe Assessment	Nursing
Brain Anatomy and Function	Nursing, Rehabilitation Services
Neurological Assessment (including stroke scale)	Nursing, Rehabilitation Services
Complications of Stroke	All Staff
Stroke Signs and Symptoms	All Staff
Stroke Medications	Nursing
Modifiable Risk Factors	All Staff
Vital Signs (expected normal ranges)	Nursing, Nursing Assistant
Dysphagia Screening, Aspiration Precaution and Specialty Diets	Nursing, Rehabilitation Services, Nursing Assistant
Depression Screening	Nursing, Rehabilitation Services
Oral care	Nursing, Nursing Assistant
Bowel and Bladder Management	Nursing, Nursing Assistant
Turning and Positioning	Nursing, Rehabilitation Services, Nursing Assistant
Skin Care	Nursing, Nursing Assistant
Nasogastric Tube Insertion	Nursing
Nasogastric and Gastrostomy Tube Care	Nursing, Nursing Assistant
Falls Risk Assessment	All Staff

conscious decision to shift gears and focus on patients in the community who could be better impacted by our services. The focus on early interventions such as secondary stroke prevention education and access to community resources, as well as care coordination with the entire care team, became a priority. As we saw success with this new approach, patient selection was expanded to include the management of hemorrhagic strokes.

With the end of the pandemic and the elimination of hospital visitation restrictions, the stroke nurse navigator no longer fully works remotely, and once again meets patients and families during the acute hospitalization. This time is used for education and explaining how the navigator will assist the patient. At present, the navigator follows the journey of a stroke patient regardless of discharge disposition, however, navigators now focus much of their attention on patients who return to the community setting. These patients have multiple touchpoints with the navigator throughout the course of the defined episode beginning immediately after the acute hospitalization. The initial outreach to the patient is completed within two business days, with the intention of identifying barriers to patient success. At minimum, the patient receives three additional touchpoints in the next 90 days. In contrast, for patients that transition to facilities, the facility is provided with continuity of care documentation and contact information for the navigator, however there is no additional engagement with the patient or facility initiated by the navigator until the patient returns to the community setting.

The key to demonstrating program success has been the implementation of a robust database, maintained by the stroke nurse navigator team. The data collected have been utilized to develop and monitor programmatic goals/outcomes, patient-specific outcomes, and to guide the future direction of the program. The database has expanded over time to capture additional key variables that impact the overall outcomes of our patients. We used our quality database to demonstrate numerous outcomes in support of the navigator role.[7-12] As a result of these findings, the funding for stroke nurse navigator positions was transitioned to our Neuroscience Institute in 2022.

Essential Stroke Navigator Functions and Program Recommendations

Based on our experience, there are several attributes and job functions that may contribute to the success of the stroke nurse navigator role. Although this role has very different responsibilities when compared to a stroke coordinator,[13] it is imperative that the coordinator and navigator work together. Both need to be experts in stroke care, current standards, clinical practice guidelines, and hospital policies and procedures (Table 3).

While the stroke coordinator needs to focus on regulatory standards and program management, the navigator focuses on patient centered care and is typically more visible to the patient and staff. This allows the navigator to assist the coordinator with staff education, chart reviews, and ensuring compliance to standards to optimize patient outcomes while also individualizing and personalizing patient care. Although our recommendations are based on high volume stroke centers, we recognize that the roles of the coordinator and navigator could be combined in a lower volume community hospital.

The stroke nurse navigator role encompasses the inpatient stroke service and management of patients in the post-acute phase of recovery. The navigator must work closely with the inpatient team to properly identify patients and to be familiar with the plan of care for those patients prior to discharge. The navigator should round with the inpatient team, when possible, otherwise there should be a clear method of communication in place between the providers and navigator to ensure that no aspect of the patient's plan of care is overlooked. After discharge, the navigator is responsible for ensuring that the patient, family, and/or facility fully understand the plan of care and can execute it, making this relationship with the inpatient team essential for success.

The stroke nurse navigator must also work closely with case management and social work as discharge planning occurs. As an advocate for the patient, it is necessary to understand levels of post-acute care and assist patients and families in establishing a safe discharge plan. Collaboration with case managers, social work, and other members of the interdisciplinary team help to identify key social determinates of health and other potential readmission risks. Identifying these potential risks allows the team to intervene prior to discharge when appropriate and can also help the navigator tailor the interventions they provide for the patient post discharge.

TABLE 3. STROKE COORDINATOR VERSUS STROKE NURSE NAVIGATOR ROLES

Stroke Nurse Navigator	Stroke Coordinator
Collaborates with providers to assess needs of the patient and family	Obtains and maintains the stroke program certification with assistance of hospital leadership
Provide program introduction to patient and families	Performs gap analysis, analyzes quality performance data to develop Performance Improvement goals
Provides support to patients, caregivers and staff across the continuum	Develops and implements annual stroke education for hospital personnel
Assist the coordinator with clinical initiatives, quality improvement projects related to the program	Provides formal and informal education to staff
Assist with formal and informal education to staff	Reviews and approves patient education
Collaborates with the multidisciplinary team for discharge planning and post-acute care	Provides community stroke education and outreach
Provides patient education related to secondary stroke prevention, medications, and plan of care	Develops evidence-based policy and procedures
Participates in ongoing professional development	Participates in ongoing professional development

To improve outcomes, patients must have proper follow-up with primary care, neurology, neurosurgery, and other specialists when appropriate. The stroke nurse navigator is responsible for ensuring these follow-ups are scheduled. Appointments should be made prior to discharge and included on patients' discharge summaries when possible. If a patient does not have an established primary care physician, one should be established for them prior to discharge from the acute hospitalization. Ideally, the navigator should have access to neurology and neurosurgery clinic schedules and have the ability to schedule these appointments based on the recommendations from the inpatient team. The navigator should encourage attendance at these appointments during each touchpoint with the patient throughout the care episode.

The stroke nurse navigator should also be responsible for post-discharge follow up phone calls for patients discharged to home. These calls are critical in identifying potential errors or clarifying instructions for patients. During the call, the navigator should review the plan of care, follow up appointments, medications, and any other instructions pertinent to the patient. Additional touchpoints throughout the episode are used to identify ongoing gaps in care, address lifestyle modification, manage post-stroke complications, and facilitate access to community resources. For patients that discharge to a facility, the navigator should ensure that the facility has the discharge summary including the plan of care and medication list, upcoming appointment dates, times, and locations, as well as the contact information for the navigator for questions or concerns that arise. Facilities are encouraged to contact the navigator as needed for assistance. The patient who transitions to the community setting within the care episode has contact initiated by the navigator at that time and continued throughout the remainder of the episode.

As an integral part of the team, stroke nurse navigators work closely with primary care providers and other specialists to ameliorate fragmented care. This is accomplished by providing the plan of care at the time of hospital discharge and communicating identified barriers to other members of the care team. Stroke nurse navigators serve as a liaison between home care, specialists, and primary care teams, and frequently advocate for additional services. These services often include social work engagement for community resources and access, psychosocial referrals, and referrals for post-stroke complications, such as spasticity, cognitive decline, and post-stroke depression and fatigue. The navigator may assist with many additional interventions including medication refills and cost reduction, assisting the family with Family Medical Leave applications, and scheduling required testing (Table 4).

It is essential that the stroke nurse navigator is well versed in stroke risk factors as well as their management. Navigators should work diligently throughout the episode of care to ensure patients and families have a thorough understanding of their personal stroke risk factors. They are responsible for providing individualized education and guidance regarding therapeutic lifestyle changes to manage risk factors such as diet, exercise, and smoking cessation. They also provide disease specific teaching and medication teaching with the goal of solidifying understanding, improving compliance, effectively influencing lifestyle change, and reducing the risk of recurrent stroke. Education should be provided via multiple modalities, including verbal instruction over the phone or in-person, written communication in the form of mailings and handouts, and/or digital communication via patient portal messaging, when available. Although this education should ideally start during the inpatient stay and continue throughout the care episode, it should be considered personalized ongoing education that does not replace the valuable education provided by bedside nurses.

We recommend that a stroke navigator follow a patient for a minimum of 90 days post discharge, at which time a functional outcome measure, such as the modified Rankin scale score, should be obtained. A 90-day episode provides ample opportunity for secondary stroke prevention education along with reinforcement of content, and it also ensures that outcome measures can be obtained on all patients.

We also recommend the development of a quality database with key metrics to measure program performance and patient outcomes. The number and type of variables included in the database may be specific to a healthcare system's population and/or programmatic goals but should be comprehensive enough to evaluate program success. Programs should refer to accrediting bodies and scientific statements for recommendations for stroke outcomes across the care continuum, although as expertise grows in stroke navigation it is likely that standardized metrics for this work will also emerge. Many navigator interventions do not directly correlate with episode cost, therefore, data play an essential role in demonstrating other

TABLE 4. NURSE NAVIGATOR INTERVENTIONS

Scheduling Primary Care (Assist in Establishing when Appropriate) Appointments
Scheduling Neurology & Neurosurgery Appointments
Scheduling Other Specialists (Cardiology, Endocrinology, etc.) Appointments
Scheduling Testing (CT, MRI, etc.) Appointments
Disease Specific Teaching
Signs & Symptoms of Stroke Education
9-1-1 Activation Education
Risk Factor Management Education
Therapeutic Lifestyle Modifications (Diet, Exercise, Smoking Cessation) Education
Education and Management of Post-Stroke Complications (Depression, Fatigue, Spasticity etc.)
Medication Reconciliation
Teaching to Improve Medication Understanding & Compliance
Prescription Cost Savings Plans
Prescription Refills
Emotional Support
Stroke Support Group Referrals
Outpatient Therapy Referrals
Assist with FMLA & Disability forms
Assist in Return-to-Work Decisions
Assist with Financial & Billing Concerns
Caregiver Resources
Transportation Assistance and Driver Evaluation Programs
Medical Record Assistance
Patient Portal Assistance
Referrals to Community Resources (Transportation, In-home Assistance Programs, Food Insecurity Programs, etc.)

important program outcomes and return on investment. At a minimum we suggest collecting the following data: Length of stay; episodes and events tied to unplanned care; navigator interventions employed; and, end of episode outcome measures such as functional status, total navigator hours, and patient/family perception of the quality of stroke services. The database should continue to evolve over time as additional important variables are identified, as well as areas of opportunity and improvement. Stroke navigators are encouraged to reevaluate and renegotiate program goals over time as the program grows and develops.

Stroke navigator teams should continuously explore alternative options to impact lifestyle changes in their patients and their families, including use of a variety of educational materials, varied educational delivery methods, and improved access to community resources. Although some of the day-to-day responsibilities may vary based on census, immediate patient needs, and other external factors such as individual social determinants of health, all navigators' ultimate responsibilities should remain facilitation of smooth transitions in care, reductions in unplanned care and hospital readmissions, and optimization of patient outcomes and experience (Figure 2). This skill set requires selection of navigators that possess an ability to adapt and change quickly, as well as those that authentically "walk the talk" through embodiment of the same healthy lifestyles advocated for by their patients.

CONCLUSIONS

The Future of Stroke Navigation

At the inception of our program, our stroke medical director, Dr. Ashis Tayal stated "Whatever you are doing today, I assure you, it will be different a year from now." It is clear through the evolution of our program that this statement reflects how our team approaches their work. As programs become more sophisticated and technologies such as artificial intelligence develop and become integrated within healthcare processes, it is possible that the navigator role may become unnecessary, however the personal nature of navigators' relationships with patients and families at what can be described as a highly vulnerable time make this unlikely at present. Programs should constantly reflect on how to expand their services, for example inclusion of patients with unusual stroke pathogenesis or those with transient ischemic attack should be considered as the role becomes embedded in organizational processes. It is likely that all forms of neurovascular disease can be significantly impacted by engagement with a stroke nurse navigator, so furthering the charge of this critical role should always be evaluated.

With now 6 full years of stroke nurse navigator service experience, we are planning to extend the length of time patients are followed by a navigator, with the goal of obtaining additional outcomes at six months and one year post hospitalization. We are hoping this extended window will further assist in influencing lifestyle modifications and reducing the risk of recurrent stroke during this crucial timeframe. We are also exploring the feasibility of a navigator clinic to enhance patients' knowledge of stroke etiology, risk factors, lifestyle modifications, and to reinforce and reiterate the plan of care that is provided during stroke follow-up appointments. Furthermore, understanding the importance of community outreach, our navigators plan to increase their presence within our network service area, with a focus on high-risk, underserved communities.

The stroke nurse navigator role will continue to evolve and change to meet the needs of our patient population, and our program goals and key performance indicators will continue to be adjusted based on the needs identified by our patients and their families. We also found that we were limited in our ability to

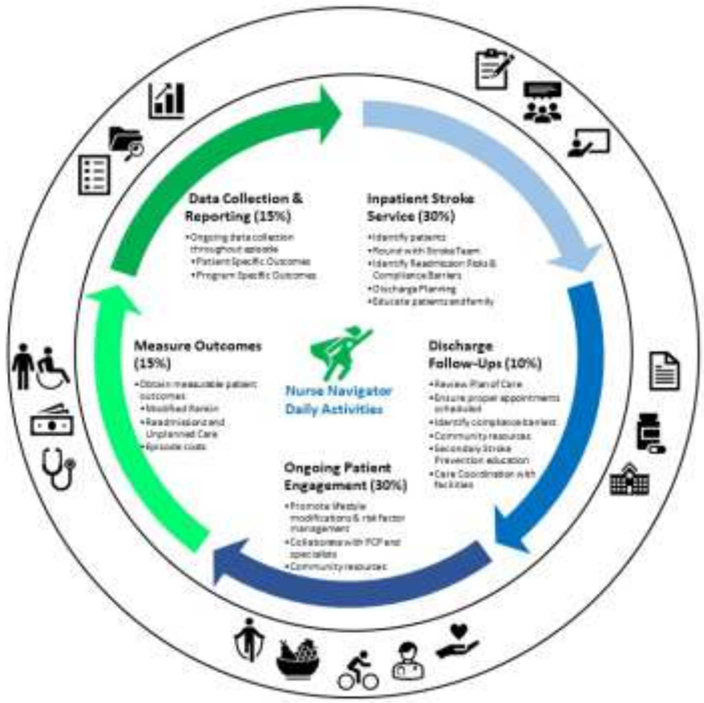


FIGURE 2: Day-to-Day Navigator Functions

impact care of stroke patients in post-acute facilities since the staffing and management of these facilities were beyond our control; however, we have had tremendous success in managing patients discharged back to the community setting after a post-acute facility admission. Future work should examine how best to collaborate with skilled nursing and rehabilitation facilities to further the scope of stroke navigation.

Summary

Stroke navigators are likely to become more prevalent over the next 5 years, and there is significant room for further innovation in role development and expansion. While our program utilizes nurses in the navigator role, other highly qualified professionals including occupational and physical therapists, as well as medical social workers and psychologists that possess knowledge of stroke pathogenesis, risk factors, secondary prevention, stroke signs and symptoms, acute stroke treatment, and community resources could also be considered for a stroke navigator role.

The journey shared in this article is meant to support others in streamlining their program development. We found it beneficial to start with a small subset of patients in the early stages of our program to allow us to better understand the role alongside patient/family needs, and to further develop the role and create tools to enhance documentation, improve data collection and better manage patient care throughout care episodes. As we became more experienced and efficient, we were able to expand the types of stroke patients enrolled and further enhance our program's contribution to stroke recovery. We strongly recommend that new programs start by focusing on the patient population that would be most highly impacted by navigator interventions before expanding too quickly to encompass all neurovascular diagnoses.

Lastly, the financial value of stroke navigators may be challenging for organizations to delineate as it is difficult to demonstrate a direct financial impact of some navigator interventions. However, careful data collection and analyses can demonstrate the value of a navigator position beyond direct financial contributions. Our robust database has demonstrated the success of this role to leadership not only through financial indicators such as decreased length of stay and decreased readmissions but also through quality metrics such as patient satisfaction, lifestyle modifications and outcomes.[7-12]

Author Affiliations

Leslie Pope, RN, MSN
Stroke Nurse Navigator
Allegheny Health Network (AHN),
Allegheny General Hospital
Pittsburgh, PA USA
leslie.pope@ahn.org

Nicole Dellostretto, LPN
Stroke Nurse Navigator
AHN, Allegheny General Hospital
Pittsburgh, PA USA
nicole.Dellostretto@ahn.org

Kelly Buchinsky, RN, MSN
Stroke Nurse Navigator
AHN, Forbes Hospital
Monroeville, PA USA
kelly.buchinsky@anh.org

Patty Noah, RN, MSN
Manager, Stroke Program
AHN, Allegheny General Hospital
Pittsburgh, PA USA
patty.noah@ahn.org

Chris Hackett, MA
Project Manager, Telestroke
AHN, Allegheny General Hospital
Pittsburgh, PA USA
chris.hackett@ahn.org

Russell Cerejo, MD
Co-Director Neuro-Endovascular Service &
Medical Director, Stroke Program
AHN, Allegheny General Hospital
Pittsburgh, PA USA
russell.cerejo@ahn.org

Ashis Tayal, MD*
Director Neuro Care Network, Telestroke &
Vascular Neurology at Wellstar Neurosciences
Marietta, GA USA
ashis.tayal@wellstar.org
*Former Cerebrovascular Program Director,
AHN Allegheny General Hospital

Corresponding Author

Patty Noah, RN, MSN
AHN Neuroscience Institute
320 East North Ave, Neuroscience Center
5th floor
Pittsburgh, PA 15212
patty.noah@ahn.org

Conflict of Interest

The authors report no conflicts of interest.

Funding

The authors report no funding to support this project or publication.

REFERENCES

1. Tsao CW, Aday AW, Almarzooq ZI, Anderson CA, Arora P, Avery CL, Baker-Smith C, Beaton A, Boehme A, Buxton A, Commodore-Mensah Y, Elkind M, Evenson K, Eze-Nliam C, Fugar S, Generoso G, Heard D, Hiremath S, Ho JE, Kalani R, Kazi DS, Ko D, Levine DA, Liu J, Ma J, Magnani JW, Michos ED, Mussolino ME, Navaneethan SD, Parikh NI, Poudel R, Rezk-Hanna M, Roth GA, Shah NS, St-Onge MP, Thacker EL, Virani SS, Voeks JH, Wang NY, Wong ND, Wong SS, Yaffe K, Martin SS; American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. Heart Disease and Stroke Statistics-2023 Update: A Report from the American Heart

Association. *Circulation*. 2023 Feb 21;147(8):e93-e621. doi: 10.1161/CIR.0000000000001123. Epub 2023 Jan 25. PMID: 36695182.

2. Duncan PW, Bushnell C, Sissine M, Coleman S, Lutz BJ, Johnson AM, Radman M, Bettger J, Zorowitz R, Stein J. Comprehensive stroke care and outcomes: time for a paradigm shift. *Stroke.* 2021;*52*(1):385-393.

3. Magwood GS, Nichols M, Jenkins C, Logan A, Qanungo S, Zigbuo-Wenzler E, Ellis Jr C. Community-based interventions for stroke provided by nurses and community health workers: A review of the literature. *Journal of Neuroscience Nursing.* 2020;*52*(4):152-159.

4. Freeman HP, Rodriguez RL. History and principles of patient navigation. *Cancer*. 2011;*117*(S15):3537-3540.

5. Camicia M, Lutz B, Summers D, Klassman L, Vaughn S. Nursing's role in successful stroke care transitions across the continuum: from acute care into the community. *Stroke*, 2021;*52*(12):e794-e805.

6. Kuehn, B. M. Nurse Navigators Cut Stroke Readmissions by Half. *Circulation,* 2022;146(2):140-141.

7. Pope L, Hackett C, Dellostretto N, Noah P, Cerejo R. Patient Engagement With Stroke Nurse Navigator Reduces Readmissions. *Stroke.* 2023;54(Suppl_1), A60-A60.

8. Dellostretto N, Hackett C, Pope L, Noah P, Cerejo R. Reduced Readmissions and Improved Outcomes In Hemorrhagic Stroke Patients Actively Involved In Post-acute Care With Nurse Navigators. *Stroke*. 2023; 54(Suppl_1):A59-A59.

9. Buchinsky K, Pope L, Noah P, Hackett C, Cerejo R. Abstract TP35: Stroke Nurse Navigation-Evolving Care Delivery To Effectively Meet The Needs Of Stroke Patients And Families. *Stroke.* 2022; 53(Suppl_1): ATP35-ATP35.

10. Pope L, Dellostretto N, Hackett C, Heintz R, Noah P, Cerejo R, Tayal AH. Predictors Of Post Stroke Discharge Follows-ups In The Stroke Clinic And Role Of A Stroke Navigator To Improve Follow-ups. *Stroke.* 2022;53(Suppl_1):A56-A56.

11. Pope L, Buchinsky K, Noah P, Hackett C, Cerejo R, Tayal AH. Virtual Care via Mobile Application Using a Patient Electronic Health Record Portal is Feasible and Increases Stroke Patient Engagement-A Pilot Study. *Stroke.* 2021;52(Suppl_1):A50-A50.

12. Pope L, Stettner P, Henderson M, Hackett C, Noah P, Cerejo R. Abstract WP426: Implementation of a Stroke Nurse Navigator in Addition to Stroke Care Path Improves Readmission Rates. *Stroke.* 2020; 51(Suppl_1):AWP426-AWP426.

13. Dusenbury W, Mathiesen C, Whaley M, Adeoye O, Leslie-Mazwi T, Williams S, Velasco C, Shah S, Gonzales N, Alexandrov AW for the American Heart Association Council on Cardiovascular and Stroke Nursing and the Stroke Council. Ideal Foundational Requirements for Stroke Program Development and Growth: A Scientific Statement From the American Heart Association. *Stroke.* 2023;54(4):e175-e187.

APPENDIX: SAMPLE JOB DESCRIPTION ELEMENTS

Description

The stroke nurse navigator serves as the consistent point of contact for referring physicians, patients, caregivers, families, and the community. Facilitates patient flow, including coordination of appointments and assists the patient with accessing clinical and supportive care services within the health system network. Coordinates all aspects of care in collaboration with the interprofessional team for all adult patients within a specialized disease state to ensure they receive quality, comprehensive services. Identifies community needs and provides education, screening, support, referrals, coordination of care, and any other assistance identified as a need.

ESSENTIAL RESPONSIBILITIES:

- Educates and coordinates care regarding patient's diagnosis, treatment options, course of treatment, clinical trial information, and available resources.
- Works with health care team to ensure safe handoff, coordination of care between facilities as well as inpatient to outpatient or outpatient to inpatient coordination of care.
- Develops or attends an existing clinical care conference to report-out on active patients to the interprofessional team.
- Works with stroke team and other community-based providers to reduce readmissions, unplanned care, and reduce length of stay.
- Trends data and outcomes as established for the navigation program. Identifies gaps to improve patient care across the continuum. May work with and/or assist registry staff with data collection, patient outcomes and updates care delivery models.
- Coordinates appointments including all aspects of the interprofessional team (physicians, consultants, supportive care services, etc. and accompanies patients as needed to appointments. Ensures that medication adherence issues are addressed).

A Stroke Transition of Care Intervention with Stroke Nurse Navigators and Early Stroke Clinic Follow-up Reduces Readmissions for Stroke at 12 Months

Kelly Matmati, MD,[1-4] Nabil Matmati, PhD,[1,3] Susan Madison, BSN, RN,[2,5,6] Brian Bixler,[2] Kelsy Vogler, BSN, RN,[2] Mary Dombovy, MD,[2] Chris Burke, MD[7]

Abstract

Background

One in four strokes occur in stroke victims, with hospital readmissions contributing to high-cost care. Transition of care programs have been successful in reducing hospital readmissions in other diseases, but the data on such programs for stroke are mixed. A transition of care program was implemented with the goal of reducing recurrent strokes and hospital readmissions.

Methods

We implemented a transition of care program using nurse navigators and early outpatient follow-up with a vascular neurologist. Data were obtained on: Rate of recurrent stroke admissions within one-year, all-cause readmission within one-year, all-cause readmission within 30 days, initial follow-up scheduled within 7-10 days, compliance with follow up, and compliance rates with provision of two-day post-hospital discharge phone calls.

Results

An improvement was seen in process measures reflecting adherence to the intervention across all 3 years. The rate of readmission for stroke at 12 months was 8.5%, 9.0%, 6.6%, and 4.2% for year 0, 1, 2, and 3, respectively, representing a 50% reduction from baseline year 0. All-cause readmission remained unchanged, at 38.9%, 42.6%, 36.6%, and 37.4% for year 0, 1, 2, and 3 respectively.

Conclusions

Our nurse navigator led stroke transition intervention was associated with significant reduction in readmissions for stroke but did not impact all cause readmission at one year or 30 days. Our focus on Centers for Medicare/Medicaid intervention compliance has produced a sustainable program capable of now expanding to support other important patient needs.

Key words: Stroke Transitions in Care; Nurse Navigator; Transitional Care Management; Readmissions.

INTRODUCTION

Out of the approximately 800,000 strokes that occur annually in the US, nearly 1 in 4 are recurrent strokes.[1] Up to 50% of stroke patients may be readmitted within 1 year. Those discharged to home have a greater chance of being readmitted compared to those discharged to rehabilitation.[2] The transition from hospital to home is a vulnerable time for these patients.

To address this vulnerable period, transitional care programs have been developed to support patients and avoid poor outcomes. Transitional care occurs when a patient is moving from one setting of care to another, for example, hospital to home. Interventions are designed to ensure continuity, care coordination, and to avoid poor outcomes at a time of risk. Such programs have been shown to reduce readmissions for chronic disease.[3] The stroke literature is mixed in showing the effectiveness of these approaches, but recently several studies have shown some benefit.[4–7]

The Centers for Medicare and Medicaid (CMS) has recognized the value of transitional care, and has incentivized this care by providing a higher level of reimbursement for transitional care compared to an outpatient visit.[8] Required CMS elements include an interactive contact within 2 days of discharge, and a follow up visit within 7 or 14 calendar days. Interactive contact is usually made by a phone call that focuses on coordination of ongoing care with agencies, assessment of medication adherence, provision of education to support self-management, and assistance with resource access. When combined with the phone call, an in-person visit within 7 days of discharge that includes high complexity medical decision making (MDM) can be billed with CPT code 99496. Billing for in-person visits within 14 days of discharge with at least moderate complexity of MDM is billed with CPT code 99495. A transitional care approach that incorporates these elements contributes towards offsetting the costs of the intervention. We report our experience with implementation of a transition of care program that aimed to improve stroke prevention and reduce hospital readmission through aggressive modification of stroke risk factors and stroke education.

METHODS

Approval and subsequent grant funding was received from the Greater Rochester Health Foundation to hire/train nurse navigators for implementation of a quality improvement transitions of care project. The primary aim of the grant was to implement a stroke and transient ischemic attack (TIA) follow-up clinic at Rochester General Hospital aimed at improving stroke prevention and hospital readmission by aggressive modification of stroke risk factors and stroke education started before hospital discharge and spanning early recovery and the period of highest risk of recurrent stroke. Rochester General Hospital is a 528-bed comprehensive stroke center hospital with an on-site stroke clinic in Rochester, New York, USA. The project was deemed Institutional Review Board (ethics) exempt. As a grant deliverable, data on outcome measures were collected beginning a year prior to the start of the project, and then on a quarterly basis for the 3-year duration of the grant. Two stroke nurse navigators were hired and trained prior to the start of data collection.

The program's interventions spanned four phases: 1) Inpatient; 2) an interactive phone call within two days post-hospital discharge; 3) stroke clinic follow up with a vascular neurologist; and, 4) ongoing follow-up for one year. During the inpatient phase, stroke navigators met their patients, provided education on stroke, and inventoried as well as educated patients on their individual personal risk factors. A standardized educational booklet about stroke that included information on stroke mechanisms, risk factors, pathophysiology, and treatment was used to support nurse navigator inpatient education. Risk factors were documented on an educational template within the electronic medical record (EMR), printed out, and provided to the patient as supplemental educational information that was placed within the stroke education booklet. Patients and family members were also taught about the FAST acronym (*F*ace drooping, *A*rm weakness, *S*peech difficulty, *T*ime to call 911) for recognizing the symptoms of stroke.[9]

A stroke clinic appointment was made prior to hospital discharge with the goal of scheduling it within 7-10 business days of discharge to home. Within two days of discharge, the navigator called the patient, reviewed their medications, reviewed the FAST acronym for symptoms of stroke, and reminded them of their appointment. Navigators also identified any barriers, such as transportation needs or inability to fill or pick up prescriptions.

At the first stroke clinic visit, the nurse navigator met the patient again, performed medication reconciliation and reinforced stroke education, assessed knowledge of the FAST acronym, and reeducated patients about personal risk factor management. All nurse navigator assessments were documented using a standard template in the EMR. Navigators also assisted with coordination of care as needed, by calling home care agencies or rehabilitation centers to ensure follow up. Remaining aspects of the stroke diagnostic workup were completed by the vascular neurologist during the clinic visit along with reassessment and management of stroke risk factors for secondary stroke prevention. Following completion of the clinic visit, patients were made aware that their nurse navigators would continue to serve as a resource capable of answering questions, providing support, and coordinating additional health services over the next 12 months. Additional follow-up clinic visits were made at 3, 6, and 12 months, and patients were also encouraged to participate in a stroke support group.

Pre-specified metrics were collected to measure the success of the program. Process measures were assessed to determine standardization of the intervention, including compliance rates with post discharge phone calls within two business days, scheduling of the initial stroke clinic appointment within 7-10 business days, and whether the stroke clinic follow up appointment was completed by the patient. Process data were recorded by the nurse navigator using the Research Electronic Data Capture (REDCap) system hosted by Rochester Regional Health.[10,11] Outcome measures included rates of all-cause readmissions within 30 days, all-cause readmissions within 12 months, and readmissions for stroke within 12 months. Outcome data were collected on patients discharged to home without hospice care and were assembled from Premier.

In keeping with the quality improvement approval for this project, patient numbers and demographics are not provided, with analyses strictly limited to the proposed process and outcome measures specified. Statistical analyses were performed using independent Student’s t-tests comparing baseline (Year 0) to Year 1, Year 2 and Year 3 of the nurse navigator intervention; p values ≤ 0.05 were considered significant. The SQUIRE 2.0 guidelines for reporting quality improvement studies were utilized to frame our article.[12]

RESULTS

Process Measures

Intervention compliance process measures demonstrated significantly improved rates for patient navigation. For two-day post-hospital discharge phone calls, no patients were called during the baseline year (year 0); however, once the transition intervention began, these calls were successfully sustained at a rate of 85% or higher ($p < 0.0001$) (Figure 1). Provision of stroke clinic appointments within 10 business days occurred rarely prior to program implementation, but increased during the intervention, reaching an average of 81% in year 3 ($p < 0.0001$)(Figure 2). Adherence to a stroke follow up appointment, regardless of timing, improved from 39% in year 0 to more than 85% in year 3 ($p < 0.0001$)(Figure 3).

Outcome Measures

The rate of readmission for stroke was 8.5% in year 0, and by year 3 was reduced to 4.2% ($p < 0.001$), representing a significant reduction of more than 50% for stroke-related hospital readmissions (Figure 4). All-cause readmission was 38.9% in year 0 and remained similar during the 3-year grant period (42.6%, 36.6%, and 37.4% for years 1, 2, and 3 respectively; p=ns) (Figure 5). Thirty-day all-cause readmissions also remained similar from baseline and over the 3-year grant period (13.6%, 17.2%, 15.3%, 15.9% for years 0, 1, 2, 3, respectively; p=ns) (Figure 6).

DISCUSSION

Our quality improvement project shows that dedicated nurse navigators were able to achieve a high rate of compliance with transition interventions, namely, completion of the two-day post-hospital discharge phone call and scheduling patients for early outpatient follow up in the stroke clinic. These interventions had a demonstrable impact on reduction of readmission for recurrent stroke within 12 months. We did not see a reduction in stroke readmissions in years 1 or 2 of the intervention, although by year 3 readmissions had been cut in half compared to baseline year 0. This improvement over the 3 years of the project likely reflects nurse navigators becoming familiar with and developing expertise in their roles, as well as improvements in project staffing, however we cannot rule out the contribution of actual patient characteristics that may have differed during these periods.

It should also be noted that the percentage of patients receiving an initial appointment within 7-10 business days, and the percentage of patients completing the first follow up visit was highest in year three, and it is likely that the early follow up visit in the vascular neurology clinic played an important role in the reduction of readmissions for stroke. These follow up visits serve to consolidate the education that patients received in the hospital and ensure that all secondary prevention measures are in place. Since behavioral changes are key to secondary stroke prevention (e.g. ensuring adherence to medications, smoking cessation, dietary changes, and exercise changes, etc.), it is likely that early follow up by nurse navigators and vascular neurologists in a stroke clinic supports improved patient adoption of preventative measures.

We did not find differences in all-cause readmissions at both three and twelve months when compared to baseline year 0. While it is unclear why the intervention did not impact all-cause readmission, this may be associated with patient characteristics that were not part of our approved quality improvement dataset. However, we also cannot rule out that the highly targeted nature of the secondary stroke prevention intervention was also associated

Figure 1: Post Discharge Phone Calls. Nurse Navigators made phone calls to stroke patients within two business days of discharge. In the baseline year, no calls were made. In years 1, 2, and 3 the rate of patients receiving calls within 2 days was significantly higher compared to baseline, at 90.1% ($p < 0.0001$), 88.5% ($p < 0.0001$), and 94.3% ($p < 0.0001$) respectively. Key: *** = p < 0.001.

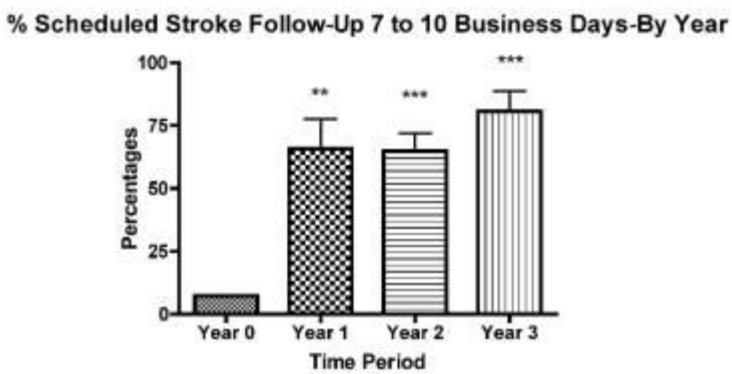
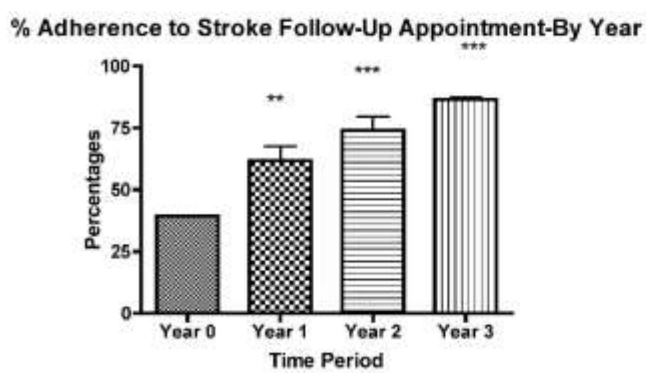


Figure 2: Percent Schedule Stroke Follow-up within 7-10 Business Days. Nurse Navigators attempted to schedule patients for stroke clinic follow-up within 10 business days of hospital discharge. This occurred in 7.3 % in baseline year 0, but was significantly higher at 65.8% ($p < 0.01$), 64.9% ($p < 0.001$), and 80.7% ($p < 0.0001$) in years 1, 2, and 3 respectively. Key: ** = p < 0.01; *** = p < 0.001.



Figures 3: Adherence to Stroke Follow-Up Appointment. Percent of patients completing a first follow-up appointment in the stroke clinic after discharge was 39.4% in baseline year 0, but was significantly higher at 61.8% ($p < 0.01$), 74.0% ($p < 0.001$), and 86.4% ($p < 0.0001$) in years 1, 2, and 3 respectively. Key: ** = p < 0.01; *** = p < 0.001.

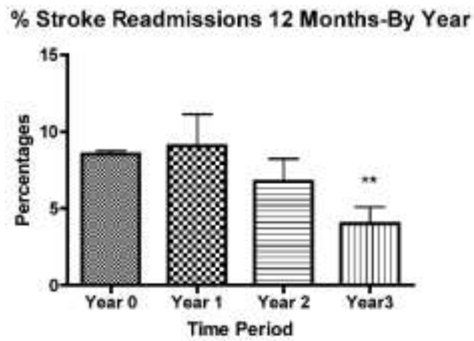


Figure 4: Stroke Readmissions at 12 Months. Percentage of stroke patients who were readmitted within one year for a stroke diagnosis was 8.5% at baseline year 0. In comparison, readmission rates for a new stroke event within 12 months of discharge were 9.0% (p = ns), 6.6% (p = ns), and 4.2% ($p < 0.01$) for years 0, 1, 2, and 3, respectively. Key: ** = p < 0.01.

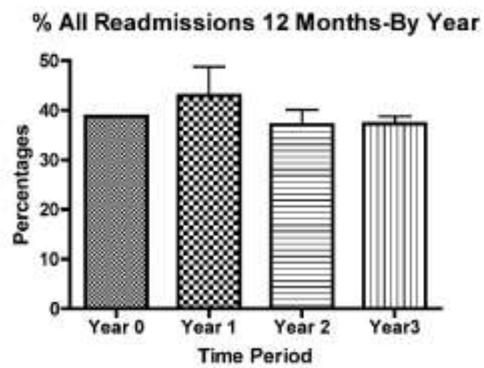


Figure 5: All Cause Readmissions at 12 Months. Percentage of patients discharged with a stroke diagnosis who were readmitted within one year for any cause remained similar at 38.9%, 42.6%, 36.6%, 37.4% for years 0, 1, 2, and 3, respectively.

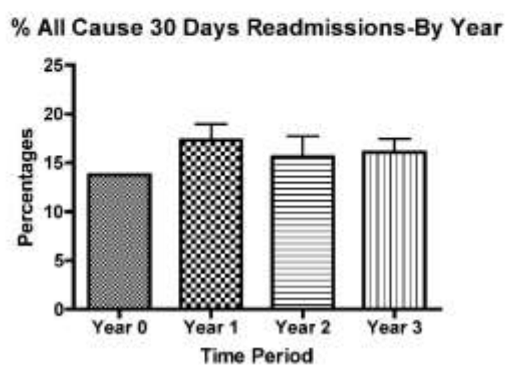


Figure 6: All Cause Readmissions at 30 Days. Percentage of patients discharged with a stroke diagnosis who were readmitted within 30 days for any cause remained similar at 13.6%, 17.2%, 15.3%, 15.9% for years 0, 1, 2, and 3, respectively.

with this finding. Future work should include collection of important patient characteristics including co-morbidities and factors tied to social determinants of health to better enable understanding of how to further develop the navigator intervention to support patient needs.

The Comprehensive Post-Acute Stroke Services (COMPASS) study[13] is the only published large randomized trial on stroke transitional care; investigators found that the intervention group showed no difference in functional outcomes at 90-days in patients discharged home after stroke, however they also found inconsistent incorporation of the COMPASS model into participating healthcare settings which may have affected study findings. Our interventions were similar to those used in COMPASS, with a two-day phone call and early outpatient follow up, but we focused intensively on nurse navigator compliance with process implementation in relation to readmission outcomes and did not include patient data. We were able to show that in a single hospital/clinic system, process metrics and readmission outcomes could be affected by a transitional care intervention. Others considering implementation of a transitions in care program should focus intently on the degree of process adherence to ensure that CMS criteria are met to a consistent degree.

Our study has limitations that must be acknowledged. First, unlike many programs including COMPASS, our project had the benefit of grant funding to support the hire, education, and training of dedicated nurse navigators whose role was tied exclusively to transitions of care. It is unknown whether programs without this level of support can successfully assist with stroke patient navigation. Second, we focused on the elements required to support CMS billing and are unable to report on how the program impacted other key patient-specific outcomes including complications, functional status, caregiver burden, and quality of life. However, by ensuring compliance with CMS requirements and reducing readmissions, our nurse navigator roles have become self-supporting, positioning us for success in examining how best to enlarge the role to impact these other important outcomes. Third, we were unable to understand whether patient characteristics may have contributed to our findings, and this information is key to fully understanding how best to develop and expand the nurse navigator role. Use of standard data fields may be important to support stroke navigation in the future, enabling comparisons between findings in different programs.

CONCLUSION

Stroke transition of care interventions supported by stroke nurse navigators and early vascular neurology follow up may play an important role in reducing admissions for recurrent stroke within the first 12 months after hospital discharge. Further exploration of the impact of transitional care interventions is warranted.

Note: This project was conducted at Rochester General Hospital, Rochester, NY, USA.

Acknowledgements: The authors wish to thank the Department of Neurology at Rochester General Hospital for their assistance and support of this project.

Source of Funding: Greater Rochester Health Foundation, Rochester, NY USA.

Conflict of Interest: The authors report no conflicts of interest related to this work.

Author Affiliations

Kelly Matmati, MD is Chair of Neurology and Stroke Program Director, St. Vincent's Medical Center, Bridgeport, CT USA;[1] vascular neurologist at Rochester Regional Health, Rochester, NY USA;[2] Assistant Professor, Department of Medicine, Frank H. Netter, MD School of Medicine, Quinnipiac University, North Haven CT USA;[3] Assistant Clinical Professor, Department of Medicine, University of Connecticut, Farmington, CT USA[4]
Kelly.matmati@hhchealth.org

Nabil Matmati, PhD is Director of Clinical Research, Ayer Neuroscience Institute, St. Vincent's Medical Center, Bridgeport, CT USA;[1] Assistant Professor, Department of Surgery, Frank H. Netter, MD School of Medicine, Quinnipiac University, North Haven, CT USA[3]
Nabil.matmati@hhchealth.org

Susan Madison, BSN, RN is Director of Ambulatory Clinical Practice, Rochester Regional Health, Rochester, NY USA;[2] Assistant Professor, St. John Fisher College[5] & Rochester General College of Health Careers, Rochester, NY USA[6]
Susan.madison@rochesterregional.org.

Brian Bixler, MBA, AEMT-P is Senior Administrator, Rochester Regional health, Rochester, NY USA[2]
Brian.bixler@rochesterregional.org.

Kelsey Vogler, RN is a Nurse Practice Manager at Rochester Regional Health, Rochester, NY USA[2]
Kelsey.vogler@rochesterregional.org

Mary Dombovy, MD is the former Executive Medical Director of Neuroscience at Rochester Regional Health, Rochester, NY USA[2]
Mary.dombovy@rochesterregional.org.

Chris Burke, MD is a neurohospitalist at Lahey Hospital and Medical Center (LHMC) Burlington, MA USA and Stroke Director, Winchester Hospital and Beverly Hospital, LHMC;[7] he was formerly a vascular neurologist at Rochester Regional Health Chris.burke@lahey.org.

Corresponding Author:
Kelly Matmati, MD.
2660 Main St.
Suite 219
Bridgeport, CT 06606
Kelly.matmati@hhchealth.org

REFERENCES

1. Tsao CW, Aday AW, Almarzooq ZI, Anderson CAM, Arora P, Avery CL, Baker-Smith CM, Beaton AZ, Boehme AK, Buxton AE, Commodore-Mensah Y, Elkind MSV, Evenson KR, Eze-Nliam C, Fugar S, et al. Heart Disease and Stroke Statistics—2023 Update: A Report From the American Heart Association. *Circulation*. 2023;147(8):e93–e621. https://www.ahajournals.org/doi/10.1161/CIR.0000000000001123
2. Kilkenny MF, Dalli LL, Kim J, Sundararajan V, Andrew NE, Dewey HM, Johnston T, Alif SM, Lindley RI, Jude M, Blacker D, Gange N, Grimley R, Katzenellenbogen JM, Thrift AG, et al. Factors Associated With 90-Day Readmission After Stroke or Transient Ischemic Attack. *Stroke*. 2020;51(2):571–578. https://www.ahajournals.org/doi/10.1161/STROKEAHA.119.026133
3. Verhaegh KJ, MacNeil-Vroomen JL, Eslami S, Geerlings SE, de Rooij SE, Buurman BM. Transitional care interventions prevent hospital readmissions for adults with chronic illnesses. *Health Affairs (Project Hope)*. 2014;33(9):1531–1539. https://doi.org/10.1377/hlthaff.2014.0160
4. Nathans AM, Bhole R, Finch CK, George CM, Alexandrov AV, March KL. Impact of a Pharmacist-Driven Poststroke Transitions of

Care Clinic on 30 and 90-Day Hospital Readmission Rates. *Journal of Stroke and Cerebrovascular Diseases: The Official Journal of National Stroke Association*. 2020;29(4):104648. https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.104648

5. McClain JV, Chance EA. The Advanced Practice Nurse Will See You Now: Impact of a Transitional Care Clinic on Hospital Readmissions in Stroke Survivors. *Journal of Nursing Care Quality*. 2020;35(2):147–152. https://doi.org/10.1097/NCQ.0000000000000414
6. Condon C, Lycan S, Duncan P, Bushnell C. Reducing Readmissions After Stroke With a Structured Nurse Practitioner/Registered Nurse Transitional Stroke Program. *Stroke*. 2016;47(6):1599–1604. https://doi.org/10.1161/STROKEAHA.115.012524
7. Poston KM, Dumas BP, Edlund BJ. Outcomes of a quality improvement project implementing stroke discharge advocacy to reduce 30-day readmission rates. *Journal of Nursing Care Quality*. 2014;29(3):237–244. https://doi.org/10.1097/NCQ.0000000000000040
8. Centers for Medicare and Medicaid. Transitional Care Management Services. *Medicare Learning Network*. 2023.
9. Anon. Stroke Symptoms. *www.stroke.org*. https://www.stroke.org/en/about-stroke/stroke-symptoms
10. Harris PA, Taylor R, Minor BL, Elliott V, Fernandez M, O’Neal L, McLeod L, Delacqua G, Delacqua F, Kirby J, Duda SN, REDCap Consortium. The REDCap consortium: Building an international community of software platform partners. *Journal of Biomedical Informatics*. 2019;95:103208. https://doi.org/10.1016/j.jbi.2019.103208
11. Pa H, R T, R T, J P, N G, Jg C. Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of biomedical informatics*. 2009;42(2). https://pubmed.ncbi.nlm.nih.gov/18929686/
12. Anon. SQUIRE | SQUIRE 2.0 Guidelines. https://www.squire-statement.org/index.cfm?fuseaction=page.viewpage&pageid=471
13. Duncan PW, Bushnell CD, Jones SB, Psioda MA, Gesell SB, D’Agostino RB, Sissine ME, Coleman SW, Johnson AM, Barton-Percival BF, Prvu-Bettger J, Calhoun AG, Cummings DM, Freburger JK, Halladay JR, et al. Randomized Pragmatic Trial of Stroke Transitional Care: The COMPASS Study. *Circulation. Cardiovascular Quality and Outcomes*. 2020;13(6):e006285. https://doi.org/10.1161/CIRCOUTCOMES.119.006285

Feasibility of a Telemedicine-Based Principal Illness Navigation (PIN) Service for Complex Populations Following Hospital Discharge After Acute Stroke

Lauren Sheehan, OTD, OTR/L,[1] Tailar Johnson, OTD, OTR/L,[1,2] Kirsten Carroll, MBA, MPH,[1] Tudor Jovin, MD[1,3]

Abstract

Background

Principal Illness Navigation (PIN) services may play an important role in helping patients through important transitions in care following acute hospitalization. We evaluated a novel PIN telemedicine approach to understand the feasibility of providing these services to diverse patient cohorts.

Methods

A single-arm, retrospective observational study of Kandu Health's post-acute PIN service was conducted in patients experiencing ischemic or hemorrhagic stroke in California and New Jersey. The technology-enabled program offered remote healthcare support led by occupational therapists and licensed clinical social workers that was tailored to individual patient needs to facilitate transition to community settings post-discharge. Barriers to recovery were addressed through patient education, one-on-one guidance, and specialized referrals. Patient outcomes were assessed through in-app assessments and clinician-assessed modified Rankin Scores conducted via video consultation. Readmissions were monitored through both patient reporting and admission/discharge/transfer feeds from health information exchanges.

Results

A total of 111 patients were enrolled between June 22, 2022 and January 11, 2024. Patients were onboarded an average of 29 ± 40 days (median 18, IQR 8-32) after acute care hospital discharge and spent an average of 81 ± 21 days (median 90, IQR 75-90) in the program. During that time, the average enrollee spent 333 ± 156 minutes (median 350, IQR 205-435) of 1:1 time interacting with their dedicated navigator, and navigators spent an additional 113 ± 87 minutes (median 95, IQR 61-140) per patient on care coordination and curriculum curation. Patients with 5 or more social determinants of health (SDOH) needs required over 50% more navigator time than those without any SDOH needs. Within 6 weeks of hospital discharge, 8.5% experienced an inpatient hospital all-cause readmission that was not associated with race, ethnicity, or SDOH.

Conclusions

High rates of enrollment and extensive patient engagement in both navigator-facilitated and self-directed program elements can be achieved using the Kandu program. Our findings indicate that telemedicine facilitated, app-supported PIN is feasible to deliver following acute stroke discharge across diverse ages, races, ethnicities, functional status (mRS), and social needs.

Key words: Stroke Navigation, Social Determinants of Health, Engagement, Readmissions.

INTRODUCTION

Patients discharged from inpatient care following stroke must navigate complex and competing factors as they embark on the dual aims of functional recovery and prevention of secondary events.[1,2,3] Barriers to recovery include physical and psychological stroke-related impairments, chronic underlying health conditions, fragmented healthcare delivery systems, insufficient insurance coverage, and inequities in social determinants of health (SDOH).[1,2] In the face of these barriers, most patients receive suboptimal post-acute care, and many deteriorate over time instead of improving.[4] A recent publication on the experiences and outcomes of young stroke survivors demonstrated that one year after stroke, 28% rated their quality of life as "poor or worse than death."[3]

Despite the best efforts by some inpatient hospital teams to prepare stroke survivors to manage their discharge instructions and follow up care, patients have a generally poor understanding of their follow-up plan.[5] Individuals who are lower income and those that have not completed high school are at higher risk of poor understanding of discharge instructions.[5]

Recent work has demonstrated the opportunity to improve stroke outcomes and underlying health conditions with behavioral health interventions. The Take Charge After Stroke (TaCAS) intervention was developed and delivered as an in-person intervention by Dr. Harry McNaughton and colleagues in New Zealand, encouraging survivors to foster a sense of purpose, autonomy, mastery, and connectedness with others.[6] Randomized clinical trials validating TaCAS have demonstrated a decrease in both dependent disability (mRS of 3-5) and overall healthcare spending at 12 months post-stroke.[7] Care partners of survivors participating in TaCAS were also less likely to experience caregiver strain.[8] Additionally, a systematic review of motivational interview-based interventions showed a statistically significant reduction in systolic and diastolic blood pressure compared with no or minimal additional intervention.[9]

The Center for Medicare and Medicaid Services (CMS) has recognized the value of healthcare navigation for patients with serious, high-risk conditions that place the patient at significant risk of hospitalization, nursing home placement, acute exacerbation/decompensation, functional decline, or death.[10] In 2024, CMS initiated reimbursement for a new category of outpatient services, called "Principal Illness Navigation (PIN)." With PIN, healthcare providers can now deliver individualized support, education and care coordination addressing both the medical and social aspects of managing a patient's disease.[11,12]

This study explored the feasibility of delivering a telemedicine-based PIN service to patients discharged to home or inpatient rehab following inpatient hospitalization for ischemic or hemorrhagic stroke. We evaluate the timing of patient engagement with PIN, the time required from clinicians to deliver the services, and how those requirements vary between demographic cohorts. We also assess preliminary operational metrics and readmission outcomes.

METHODS

We conducted a retrospective, single-arm, observational study of a post-acute PIN service provided by Kandu Health that was delivered to patients in partner facilities experiencing ischemic or hemorrhagic stroke in California and New Jersey.

The Kandu Program

Kandu's program is a tech-enabled, fully remote healthcare service that was co-designed by clinicians and stroke survivors to support patients as they return to community settings after inpatient discharge. Patients and their care partners were assigned a dedicated navigator who provided consistent support for the entire duration of the program. Navigators were occupational therapists (OTs) and licensed clinical social workers (LCSWs) with experience caring for stroke patients and specialized training in navigation best practices, motivational interviewing, and case management. Navigators worked within a multidisciplinary Kandu clinical team encompassing broad facets of stroke recovery including physiatry, mental health specialists, neuro-optometry, occupational therapy and medical nutrition support. Patients are referred to outside specialists including neurology, allied health and rehabilitation providers, as needed. The Kandu clinical team participated in regular case conferences and was available for specialty consults. Patients interacted with clinicians through video consultations, telephone calls, and in-app messaging.

Navigators assisted patients with understanding and prioritizing their discharge plan, addressing each individual's barriers to recovery, such as limited health literacy or stroke-related impairments. They provided education and guidance on next steps in their journey to maximize their recovery potential. As part of program implementation with partner hospitals, resources were gathered in the various domains pertinent to the Accountable Health Communities (AHC) Social Needs Screening Tool[13] (Figure 1) and cross-walked to the SDOH needs identified for each enrollee. Resource maps were populated with hospital, hospital system, local community, national, and virtual resources so that navigators could support enrollees across differing insurance carriers and diverse geography.

Navigators designed a curated learning curriculum for each stroke survivor and care partner, delivered through the app with a unique combination, sequence, and timing of articles tailored to their specific impairments and post-stroke needs. The available library includes over 600 articles that were co-written with source documentation and editorial oversight by stroke survivors, care partners, and clinicians representing 10 medical disciplines. The curriculum was informed by self-determination theory, which encourages participants to "take charge" of their life and health after a stroke.

Each enrollee was offered a navigator-facilitated TaCAS session between weeks 6-8 of the program. Participants could record in their workbooks and pursue additional self-directed learning sessions in the Kandu app. As a complement to TaCAS, navigators utilized a motivational interviewing approach to support survivors with management of stroke risk factors including blood pressure

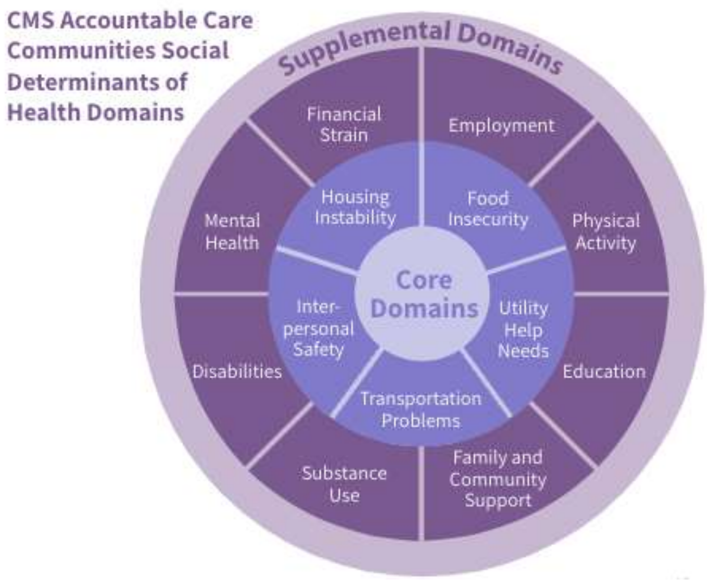


Figure 1: Centers for Medicare and Medicaid Services (CMS) Accountable Health Communities (AHC) Social Needs Screening Tool cross-walked with social determinants of health domains.

control, dietary changes, stress management, and other general health behavior changes to reduce subsequent stroke risk.

The program encouraged community connection through “Connect” groups, to which enrollees were assigned by role (survivor or care partner) and circumstances. In addition to asynchronous in-app message boards, several virtual video-based Connect groups were offered each week for survivors and care partners to connect with their peers. The Connect groups offered a space for individuals to review their own lived experiences, reduce social isolation, and provide or receive support throughout their stroke recovery. The sessions were led by Kandu Ambassadors made up of stroke survivors and care partners with lived experience and training in peer support facilitation.

For a survivor to be considered ready to “graduate” from the Kandu program, they need to demonstrate achievement of a majority of the characteristics or desired outcomes depicted in Figure 2. This model allowed the Navigator team flexibility in survivor self-determination and goal setting while adhering to objective criteria for program completion.

Study Management

At each site, referrals and sharing of protected health information (PHI) were governed by approved administrative contracts and Business Associate Agreements (BAAs). Subjects were included based on consecutive enrollment from the date of program inception. All data were collected and stored in Kandu Health’s medical records. Patients were referred to the program from a variety of sources, including acute care hospitals, outpatient clinics, inpatient rehabilitation facilities, and community support groups. Referring parties were directed to refer ischemic or hemorrhagic stroke patients if they had access to a smartphone, spoke English, were expected to be returning to a community setting, and were able to consent to services; no exclusion criteria were utilized.

Figure 2: Kandu Program Completion Criteria

Study Endpoints

Patient reported outcome measures (PROMs) were collected through in-app assessments, while modified Rankin Scores (mRS) were assessed by navigators over video consultation at enrollment, 30 days, and 90 days post-discharge. During program onboarding, navigators assessed patients' social determinants of health (SDOH) using the AHC Social Needs Screening Tool. Person-centered assessments were also conducted so that patient goals and living situations could be understood and better contextualized alongside the discharge plan, enabling individualized recovery priorities to be set. Readmissions were monitored through both patient reporting and admission-discharge-transfer feeds from health information exchanges. Navigator minutes were tracked in the electronic medical record (EMR) and through use of Toggl time tracking software. For the purposes of this study, readmissions were defined as any post-discharge acute care hospital stay for any cause lasting at least 2 midnights. Differences in proportions of readmissions between groups were examined by Chi-Square analyses; differences in continuous measures (navigator minutes and days to program enrollment) were examined using one-factor ANOVA.

Results

Between June 22, 2022 and January 11, 2024, 249 patients were referred to the Kandu program; 131 (52.6%) patients declined to enroll, and 7 were still in-program at the time of this data analysis, with complete data available for analysis in 111 patients. Of these, 104 (93.6 %) completed all criteria for program graduation, 1 (0.9%) died, and 6 (5.4%) discontinued before completing the program.

The volume and complexity of patient referrals from the participating hospitals grew each quarter, with average monthly enrollment more than doubling from the beginning to the end of the study period. The proportion of patients choosing to enroll following their referral remained consistent through the study period.

Patient Demographics

The average patient age at the time of referral was 59 ± 14 years (median 62, IQR 48-69); 52% were men and 68% co-enrolled with a

Figure 3: Most prevalent stroke survivor social needs as assessed by the AHC Screening Tool.

care partner. Patients were 59% White, 30% Black, 10% Asian, and 1% Native American; 14% were of Hispanic/Latino ethnicity. The median modified Rankin Score (mRS) was 2 (IQR 1-3); 48% had dependent disability (mRS 3-5) on enrollment. Insurance status was 42% commercial health plans, 31% Medicare, and 27% Medicaid or uninsured. The median number of SDOH needs per patient was 2 (IQR 0-4), with 23% of enrollees having 5 or more SDOH needs. Figure 3 shows the distribution of the most prevalent SDOH needs identified by the AHC Screening Tool for the cohort.

Operational Metrics

Enrollees onboarded an average of 29 ± 40 days (median 18, IQR 8-32) after acute hospital discharge and spent an average of 81 ± 21 days (median 90, IQR 75-90) in the program. During that time, the average enrollee spent 333 ± 156 minutes (median 350, IQR 205-435) of 1:1 time interacting with their dedicated navigator, and navigators spent an additional 113 ± 87 minutes (median 95, IQR 61-140) per patient on care coordination and curriculum curation. The total navigator time per patient averaged 446 ± 209 minutes (median 447, IQR 280-589).

The Take Charge intervention was completed by 67% of patients, and 82% took part in a Kandu "Connect Group". Of the 21 patients who did not have an existing primary care provider (PCP) at enrollment, 95% of these successfully established a PCP by program completion. Among patients enrolled in the program within 6 weeks of hospital discharge, 89% confirmed completion of a neurology follow up by program completion.

The Kandu app was activated and used by 90% of stroke survivors enrolled in the program. The average stroke survivor spent 271 ± 323 minutes (median 173, IQR 51-393) in the app and read 32 ± 39 articles (median 18, IQR 0-57). Among the 35 survivors who did not complete any in-app readings, 49% had a care partner who completed readings instead.

The average survivor received 2.8 ± 3.5 resource connections (median 2, IQR 1-3) from their navigator to support both their medical and SDOH needs. The top 5 categories of resource connections were Healthcare, Rehabilitation, Mental Health, Transportation, and Equipment.

Over the course of program enrollment, 55% of enrollees had at least one no-show for a scheduled navigator appointment, with the average enrollee having 1.5 ± 2.2 (median 1, IQR 0-2) no-shows. In total, 13.1% of scheduled appointments with enrollees were no-shows.

Table 1 describes the demographics, operational metrics, and 90-day readmission rates among Kandu enrollees. In most cases, the program experience was consistent across

		Number	Proportion	Navigator 1:1 Minutes	*p-value*	Days btw Discharge & Onboarding	*p-value*	90d Readmission Rate	p-value
All		111	100.0%	333 ± 156		29 ± 40		8.5%	
Gender									
	Male	58	52.3%	321 ± 176	*0.42*	27 ± 47	*0.57*	9.4%	0.72
	Female	53	47.7%	345 ± 132		31 ± 32		7.3%	
Age									
	<65	68	61.3%	344 ± 160	*0.34*	29 ± 36	*0.92*	5.4%	0.18
	65+	43	38.7%	315 ± 151		29 ± 47		13.2%	
Race									
	White	65	58.6%	311 ± 161		32 ± 44		8.9%	
	Black	33	29.7%	381 ± 143	*0.09*	19 ± 17	*0.13*	10.3%	0.56
	Asian	11	9.9%	300 ± 143		45 ± 59		0.0%	
Ethnicity									
	Hispanic/Latino	15	13.5%	309 ± 132	*0.53*	20 ± 18	*0.35*	0.0%	0.22
	Non Hispanic/Latino	96	86.5%	336 ± 160		31 ± 43		10.0%	
Co-Enrolled with Care Partner									
	Yes	76	68.5%	337 ± 161	*0.70*	33 ± 43	*0.15*	11.3%	0.18
	No	35	31.5%	324 ± 148		21 ± 32		3.1%	
Primary Insurance Source									
	Commercial	47	42.3%	306 ± 152		35 ± 41		10.5%	
	Medicare	34	30.6%	322 ± 147	*0.08*	32 ± 51	*0.16*	10.7%	0.83
	Medicaid or Uninsured	30	27.0%	386 ± 164		17 ± 17		3.6%	
Number of SDOH Needs									
	0	29	26.1%	268 ± 140		20 ± 27		7.4%	
	1-4	56	50.5%	331 ± 137	***0.003***	33 ± 38	*0.35*	14.0%	0.43
	5+	26	23.4%	408 ± 182		30 ± 56		0.0%	
Referral Source									
	ACH	73	65.8%	340 ± 154		16 ± 17		8.7%	
	IRF	12	10.8%	295 ± 137	*0.48*	29 ± 15	***<.0001***	10.0%	0.91
	Outpatient Clinic	11	9.9%	285 ± 159		67 ± 42		0.0%	
	Community	15	13.5%	364 ± 181		65 ± 80		10.0%	
Post-Stroke Impairments									
	Neither	39	35.1%	368 ± 166		17 ± 23		10.8%	
	Aphasia	38	34.2%	329 ± 137	*0.26*	28 ± 35	***<.0001***	12.1%	0.39
	Hemiparesis	24	21.6%	289 ± 147		25 ± 21		0.0%	
	Aphasia + Hemiparesis	10	9.0%	315 ± 196		89 ± 84		0.0%	
mRS at Program Enrollment									
	0-2	56	50.5%	351 ± 152	*0.27*	28 ± 46	*0.94*	10.4%	0.52
	3-5	53	47.7%	319 ± 160		28 ± 27		6.7%	
Stroke Type									
	Ischemic	92	82.9%	329 ± 154		28 ± 42		7.5%	
	Hemorrhagic	10	9.0%	344 ± 203	*0.85*	33 ± 38	*0.78*	12.5%	0.87
	Other/Unknown	9	8.1%	357 ± 129		37 ± 27		16.7%	
Post-ACH Discharge Disposition									
	Home	73	65.8%	343 ± 153	*0.83*	25 ± 42	*0.91*	9.2%	0.81
	Inpatient Rehab	31	27.9%	336 ± 163		28 ± 23		7.7%	

Table 1: Demographic subsets, operational metrics, and 90-day readmission rates. Data not reported for cohorts less than 9 patients. Readmissions only reported among patients who enrolled within 6 weeks of acute care hospital (ACH) discharge. SDOH = social determinants of health; IRF = inpatient rehabilitation facility.

Patient	Cause	Timing of Readmission: Days Post Discharge	Timing of Readmssion: Program Day	Days Between Index Discharge and Program Onboarding
1	Hypertensive Crisis	2	1	1
2	Recurrent Stroke	27	21	6
3	GI Bleed	73	45	28
4	Seizure	77	-23	100
5	Hypertensive Crisis	50	39	11
6	COVID	56	44	12
7	Cancer	9	13	-4
8	Recurrent Stroke	20	15	5
9	Lupus	45	0	45
10	Food Poisoning	43	9	34

Table 2: All-cause 90-day readmissions in the cohort.

subgroups, with a few cohorts demonstrating significant relationships to operational quality metrics.

The time that navigators spent with patients increased with the number of SDOH needs. Patients with 5 or more SDOH needs required over 50% more navigator time than those without any SDOH needs. Clinician-assessed SDOH needs were more strongly correlated with navigator time than primary insurance status. However, the need for navigator support was not limited to patients with high SDOH. Even those patients without any SDOH needs required 268 ± 140 minutes (median 257, IQR 145-370) of 1:1 navigator support and 117 ± 80 minutes (median 100, IQR 74-143) of care coordination and curriculum curation from their navigators.

Referral from an acute care hospital or inpatient rehabilitation facility was correlated with a shorter delay between hospital discharge and program onboarding. As detailed in Table 1, patients referred from these inpatient institutions were typically onboarded within a month of discharge, while those referred from outpatient clinics or community groups were not onboarded until the third month after discharge. Patients experiencing aphasia and hemiparesis were more likely to have a late referral, reflected in longer average days between acute hospital discharge and program enrollment.

Readmissions

A total of 10 program participants experienced a readmission within 90 days of hospital discharge. Among the 94 patients who enrolled in the program within 6 weeks of hospital discharge, 8.5% experienced an inpatient readmission. Readmission was not associated with race, ethnicity, or SDOH. Table 2 presents readmission data for the cohort.

DISCUSSION

Despite the high rates of stroke worldwide, there remains a considerable lack of multidisciplinary post-acute stroke support available to survivors as they return to community settings after inpatient discharge. Many stroke survivors and care partners experience a loss of identity, challenges with managing daily activities, difficulty adapting to life after a stroke, and limited access to services or emotional support.[14,15,16] PIN is well positioned to treat post-acute stroke as a chronic condition, assisting stroke survivors and their care partners with comprehensive, survivor-specific care plans and multi-disciplinary support after hospital discharge.

Our findings indicate that navigator facilitated, app-supported PIN is feasible to deliver following acute stroke discharge across age, race, ethnicity, functional status (mRS), and social needs. With recently published readmission rates ranging from 8.7 to 12.5% at 30 days post-stroke discharge, and 18.9 to 20.7% at 90 days,[17,18] it is imperative to engage with patients as soon as possible once they return to community settings. In this cohort, partnerships with acute care hospitals and inpatient rehab facilities were critical to achieving early onboarding. While CMS rules mandate that PIN be preceded by a prescription from an outpatient evaluation and management visit,[10] referral to that outpatient visit and introduction to the concept of PIN in post-stroke care should ideally occur as part of a patient's discharge planning process.

CMS coverage of PIN services was born out of decades of work in cancer navigation,[19] which has demonstrated the ability of navigation to reduce health disparities and improve patient outcomes, while establishing standards for the ethics, qualifications, knowledge, skills, activities and supervision of navigators.[20] While the CMS coverage decision allows for PIN services to be delivered to stroke patients, the standards for PIN after stroke are less well understood. Where cancer models largely rely on nurses and social workers for navigator services, our post-acute stroke program was delivered by OTs and LCSWs with stroke-specific experience and training, demonstrating acceptable feasibility; this is an important finding, given the tremendous need for navigators and a shortage of registered nurses.

We also found that, as anticipated by the 2024 CMS physician fee schedule final rule, stroke survivors have complex post-acute needs and require large amounts of navigator time to effectively respond to those needs. To bill for PIN services, a minimum of 60 cumulative minutes of care must be delivered in a calendar month. Recognizing how challenging some cases can be, there are no limitations on the number of times that an additional 30-minutes of services can be billed in a month.[11] In our 12-week program, the average month of PIN services for stroke survivors required nearly 2.5 hours of navigator time, and stroke survivors with high SDOH needs (greater than 5) required over 50% more time than those without any SDOH needs. These findings will be useful to plan and budget for future navigator staffing needs, making them key metrics for collection by all navigator programs.

The complex dynamics of both a survivor's SDOH needs, like housing and food insecurity, and post-stroke impairments, like memory deficits and post-stroke fatigue, can result in stroke survivors being a uniquely difficult population to consistently engage.[21,22,23] No-shows and cancellations are to be expected in this population and persistence and empathy are important to accommodate survivors' changing needs. We found that the telehealth delivery used in our program can reduce disparities in access to care for a population that is often confined to home, limited in access to transportation, and experiencing social isolation and stigma. The program achieved high rates of enrollment and extensive patient engagement in both navigator-facilitated and self-directed program elements. This was achieved by addressing barriers to digital literacy, co-designing with stroke survivors, utilizing navigators to assist with digital literacy challenges, and utilizing other methods like texting, secure in-app messaging and other solutions that do not require access to high-speed internet.[21]

As half of referred patients elected not to enroll, we will continue working to understand the most effective timing, channels and messaging to increase the proportion of patients that enroll in PIN services following referral. It was important, during the course of this study, to dedicate personnel and resources to the onboarding and enrollment process, separate from and complementary to clinical service providers. With continuous learning, and development of best practices, we were able to significantly increase both the volume and complexity of referred patients without experiencing reductions in successful patient enrollment.

The 90-day readmission rates in this cohort compare favorably to published literature, and the causes of readmission were diverse and not atypical for this patient population based on previous publications. In this small cohort, there were no trends or associations between readmission rates and demographic or operational metrics.

Limitations

Our study is limited by use of a self-selected, single-arm cohort, with most patients screened for program appropriateness by facility-based clinicians at partner hospitals prior to referral. As such, we cannot determine the extent to which the outcomes and patient engagement in this population were driven by patient selection vs. the quality of the clinical care, or whether the program definitively improved patient outcomes. The study population, while diverse, and with meaningful representation across broad demographic cohorts, includes a younger distribution of patients than typically seen in stroke. However, it is well documented that the median age of stroke is changing globally, with 67% of stroke survivors now under the age of 70,[24,25] making this a critical population to study. In addition to age differences, important segments of the population, like those who did not speak English, had very limited digital literacy, or lacked access to necessary technologies (smartphones) were not included. Further research in expanded populations, and using propensity-matched controls, or a randomized clinical trial approach, will strengthen our knowledge of the contribution of PIN to patient outcomes. Lastly, we made extensive efforts to capture and include all readmissions, utilizing both self-reporting by highly engaged patients and third-party monitoring of data through admission-discharge-transfer feeds in health information exchanges. Despite this proactive monitoring, it is possible that some readmissions were missed, potentially making our reporting incomplete.

Future Research

In addition to the aforementioned propensity-matched and randomized studies, there is opportunity to explore the utility of outcomes beyond those traditionally used in stroke clinical trials. The primary endpoint for nearly all studies in stroke treatment has traditionally been a dichotomized mRS, with any score from 0-2 on the 7-point schedule considered a “good outcome”. With the patient engagement afforded by effective digital health tools and outpatient services, a broader set of patient-reported measures can be collected, and with greater frequency, including PHQ 2/9 for depression, GAD-7 for anxiety, and the PROMIS Global 10 measures for general, physical, and mental health. Further research is required to establish associations between these patient-reported outcomes measures and modified Rankin Scores, as well as minimal clinically important differences for these measures in the stroke population.

Due to the pilot nature of this study, we limited access to the program to English speaking individuals and to those with access to the internet. It is imperative that future studies address the reduced generalizability derived from this approach by extending inclusion to individuals not represented in this study, who by nature of their exclusion represent a patient population particularly in need of enhanced post stroke discharge care.

Importantly, with the conduct of assessment comes an ethical obligation to be prepared to respond when problems are revealed by those assessments. PIN services provide a novel vehicle to do so. Those delivering PIN services, whether for research or as part of standard clinical care, should be prepared with escalation plans and resource maps to respond to diverse time-sensitive needs including food and housing insecurity, domestic violence, suicidal ideation, recurrent stroke, infections, and sepsis.

Finally, future research can better establish which components of PIN are most critical to achieving improved patient outcomes and how much that varies across demographic cohorts. For example, how much is too much, or not enough, and which interventions, resources, and tools are used most frequently and to best effect? Multivariate analysis of operational metrics and demographics relative to outcomes in a larger cohort of patients will be critical to teasing out these insights.

CONCLUSIONS

Principal illness navigation for stroke survivors and care partners has the potential to enhance the patient and care partner experience early in their recovery process, establish connectivity with others during a time of vulnerable isolation, increase access to stroke and wellness education and clinical resources during home and community reintegration, and improve patient outcomes.[26,27] This study demonstrates the feasibility of enrolling and engaging patients with diverse and complex physical and psychosocial needs in these services utilizing a remote, outpatient telehealth service in the days to months following stroke discharge.

Acknowledgements:

The authors wish to thank their partners at Cedars-Sinai, Los Angeles, California USA and Cooper University Hospital, Camden, New Jersey USA for their participation in this study.

Source of Funding:

Kandu Health, Campbell, California USA

Conflicts of Interest:

Lauren Sheehan, Tailar Johnson, and Kirsten Carroll are employed by the study sponsor, Kandu Health; Dr. Jovin is the Chief Medical Officer at Kandu Health.

Author Affiliations

Lauren Sheehan, OTD, OTR/L
Senior Director of Clinical Services
Kandu Health, Campbell, California USA[1]
lsheehan@kanduhealth.com

Tailar Johnson, OTD, CNP
Researcher
Kandu Health, Campbell, California USA[1]
Occupational Therapist
Foundations Therapy Service[2]
tjohnson@kanduhealth.com

Kirsten Carroll, MBA, MPH
Chief Executive Officer
Kandu Health, Campbell, California USA[1]
kcarroll@kanduhealth.com

Tudor Jovin, MD
Chief Medical Officer, Kandu Health, Campbell, California USA[1]
Chairman and Chief of Neurology
Cooper University Hospital
Medical Director, Cooper Neurological Institute
Professor of Neurology and Neurosurgery
Cooper Medical School of Rowan University[3]
jovin-tudor@cooperhealth.edu

Corresponding Author

Lauren Sheehan, OTD, OTR/L
Senior Director of Clinical Services
Kandu Health
210 East Hacienda, Campbell, California USA
lsheehan@kanduhealth.com

REFERENCES

1. O'Callaghan G, Fahy M, Murphy P, Langhorne P, Galvin R, Horgan F. Effectiveness of interventions to support the transition home after acute stroke: a systematic review and meta-analysis. *BMC Health Services Research*. 2022;22(1). doi:https://doi.org/10.1186/s12913-022-08473-6

2. Reeves MJ, Boden-Albala B, Cadilhac DA. Care Transition Interventions to Improve Stroke Outcomes: Evidence Gaps in Underserved and Minority Populations. *Stroke*. 2023;54(2):386-395. doi:https://doi.org/10.1161/strokeaha.122.039565

3. Walters R, Collier JM, Braighi Carvalho L, et al. Exploring post acute rehabilitation service use and outcomes for working age stroke survivors (≤65 years) in Australia, UK and South East Asia: data from the international AVERT trial. *BMJ Open*. 2020;10(6):e035850. doi:https://doi.org/10.1136/bmjopen-2019-035850

4. ElHabr AK, Katz JM, Wang J, et al. Predicting 90-day modified Rankin Scale score with discharge information in acute ischaemic stroke patients following treatment. *BMJ Neurology Open*. 2021;3(1):e000177. doi:https://doi.org/10.1136/bmjno-2021-000177

5. Sheikh H, Brezar A, Dzwonek A, Yau L, Calder LA. Patient understanding of discharge instructions in the emergency department: do different patients need different approaches? *International Journal of Emergency Medicine*. 2018;11(1). doi:https://doi.org/10.1186/s12245-018-0164-0

6. Fu V, Weatherall M, McPherson K, et al. Taking Charge after Stroke: A randomized controlled trial of a person-centered, self-directed rehabilitation intervention. *International Journal of Stroke*. 2020;15(9):174749302091514. doi:https://doi.org/10.1177/1747493020915144

7. Te Ao B, Harwood M, Fu V, et al. Economic analysis of the "Take Charge" intervention for people following stroke: Results from a randomised trial. *Clinical Rehabilitation*. 2021;36(2):240-250. doi:https://doi.org/10.1177/02692155211040727

8. Boehme C, Toell T, Lang W, Knoflach M, Kiechl S. Longer term patient management following stroke: A systematic review. *International Journal of Stroke*. 2021;16(8):917-926. doi:https://doi.org/10.1177/17474930211016963

9. Huang X, Xu N, Wang Y, Sun Y, Guo A. The effects of motivational interviewing on hypertension management: A systematic review and meta-analysis. *Patient Education and Counseling*. 2023;112:107760. doi:https://doi.org/10.1016/j.pec.2023.107760

10. CMS Finalizes Physician Payment Rule that Advances Health Equity | CMS. www.cms.gov. https://www.cms.gov/newsroom/press-releases/cms-finalizes-physician-payment-rule-advances-health-equity

11. Federal Register :: Request Access. unblock.federalregister.gov. https://www.federalregister.gov/documents/2023/11/16/2023-24184/medicare-and-medicaid-programs-cy-2024-payment-policies-under-the-physician-fee-schedule-and-other

12. Center for Medicare and Medicaid Services. Health Equity Services in the 2024 Physician Fee Schedule Final Rule. Published 2024. Accessed March 25, 2024. Available from: https://www.cms.gov/files/document/mln9201074-health-equity-services-2024-physician-fee-schedule-final-rule.pdf-0

13. Accountable Health Communities Model | CMS. Published May 1, 2017. Accessed March 1, 2024. Available from: https://www.cms.gov/priorities/innovation/innovation-models/ahcm

14. Martin-Saez MM, James N. The experience of occupational identity disruption post stroke: a systematic review and meta-ethnography. *Disability and Rehabilitation*. 2019;43(8):1-12. doi:https://doi.org/10.1080/09638288.2019.1645889

15. McCarthy M, Lyons K, Schellinger J, Stapleton K, Bakas T. INTERPERSONAL RELATIONSHIP CHALLENGES AMONG STROKE SURVIVORS AND FAMILY CAREGIVERS. *Innovation in Aging*. 2018;2(suppl_1):963-963. doi:https://doi.org/10.1093/geroni/igy031.3567

16. Pereira CM, Greenwood N, Jones F. From recovery to regaining control of life – the perspectives of people with stroke, their carers and health professionals. *Disability and Rehabilitation*. Published online February 8, 2020:1-12. doi:https://doi.org/10.1080/09638288.2020.1722263

17. Bushnell C, Kucharska-Newton A, Jones S, et al. Hospital Readmissions and Mortality Among Fee-for-Service Medicare Patients With Minor Stroke or Transient Ischemic Attack: Findings From the COMPASS Cluster-Randomized Pragmatic Trial. 2021;10(23). doi:https://doi.org/10.1161/jaha.121.023394

18. Ramchand P, Thibault DP, Crispo JA, et al. Readmissions After Mechanical Thrombectomy for Acute Ischemic Stroke in the United States: A Nationwide Analysis. *Journal of Stroke and Cerebrovascular Diseases*. 2018;27(10):2632-2640. doi:https://doi.org/10.1016/j.jstrokecerebrovasdis.2018.05.035

19. Cancer Navigation Improves Equity & Outcomes – Paying for It Matters, Too | OSTP. The White House. Published November 27, 2023. Accessed March 29, 2024. https://www.whitehouse.gov/ostp/news-updates/2023/11/27/cancer-navigation-improves-equity-outcomes-paying-for-it-matters-too/

20. Lisa Simms Booth BA. Oncology Navigation Standards of Professional Practice. *wwwjons-onlinecom*. Published online March 28, 2022. https://www.jons-online.com/issues/2022/march-2022-vol-13-no-3/4399-oncology-navigation-standards-of-professional-practice

21. Sharrief AZ, Guzik AK, Jones E, et al. Telehealth Trials to Address Health Equity in Stroke Survivors. *Stroke*. 2023;54(2):396-406. doi:https://doi.org/10.1161/strokeaha.122.039566

22. Amytis Towfighi, Boden-Albala B, Cruz-Flores S, et al. Strategies to Reduce Racial and Ethnic Inequities in Stroke Preparedness, Care, Recovery, and Risk Factor Control: A Scientific Statement From the American Heart Association. Published online May 15, 2023. doi:https://doi.org/10.1161/str.0000000000000437

23. SINGER A, Richardson AM, Reichwein RK, Cekovich E. Abstract 31: Let Me Be Your Guide: The Impact of Stroke Navigators on Post-Acute Stroke Follow Up. *Stroke*. 2024;55(Suppl_1). doi:https://doi.org/10.1161/str.55.suppl_1.31

24. U.S. stroke rate declining in adults 75 and older, yet rising in adults 49 and younger. American Heart Association. https://newsroom.heart.org/news/u-s-stroke-rate-declining-in-adults-75-and-older-yet-rising-in-adults-49-and-younger

25. World Stroke Organization. *Global Stroke Fact Sheet*. World Stroke Organization; 2022. https://www.world-stroke.org/assets/downloads/WSO_Global_Stroke_Fact_Sheet.pdf

26. Lin S, Wang C, Wang Q, et al. The experience of stroke survivors and caregivers during hospital-to-home transitional care: A qualitative longitudinal study. *International Journal of Nursing Studies*. 2022;130:104213. doi:https://doi.org/10.1016/j.ijnurstu.2022.104213

27. Upadhyay S, Stephenson AL, Smith DG. Readmission Rates and Their Impact on Hospital Financial Performance: A Study of Washington Hospitals. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*. 2019;56(56):004695801986038. doi:https://doi.org/10.1177/0046958019860386

Emerging Post-Hospital Models of Care: A Primer for Stroke Center Leaders

Sarah Livesay, DNP, APRN, FNCS, FAAN & Debbie Hill, BS, FAHA

Abstract

After discharge, stroke survivors are at high risk for secondary stroke as well as readmission to a hospital. While stroke center certification standards emphasize preparing patients and caregivers for discharge, patients discharged to home may experience delays in seeing a community provider and report inadequate preparation for discharge. Several models suggest inpatient stroke programs are assuming additional roles and responsibilities in the management of patients after discharge. Models such as a stroke nurse navigator, post-stroke clinics and other interdisciplinary supported discharge programs may address gaps in care after discharge. Even with this evidence, stroke leaders should evaluate their own patient outcomes to understand their needs and plan services accordingly. Strategies to evaluate discharge outcomes and advocate for services are discussed.

Keywords: stroke, stroke navigation, stroke clinics, care transitions, post-discharge care.

Introduction

As new therapies were developed for treatment of acute ischemic stroke, the network of certified stroke programs evolved to ensure early treatment was available for all who suffer stroke.[1] Protocols and pathways were developed that prioritized the minutes and hours of care after arrival to ensure treatments were administered to maximize patient survival and functional recovery. However, transition from hospital to post-acute care, regardless of the level of care required, is often fraught with challenges. Stroke survivors often report specific and unique challenges at the time of discharge from their acute stroke event.[2] After hospital discharge, stroke survivors are at high risk for readmission to the hospital within 90 days of discharge and are also at risk for a subsequent stroke event.[3] Additionally, stroke survivors often have comorbidities that require further management to prevent another stroke and may suffer new disability increasing the likelihood of a fall or other accident after discharge.[4]

Background

Stroke survivors who are discharged from the hospital to home instead of another facility face unique challenges. One qualitative study reported patients and family of patients with stroke who were discharged home struggled with insufficient services and information, unsatisfactory relationships with their healthcare providers, and mental distress.[2] Because the acute stroke admission is often short, stroke survivors may lack continuity of care related to medication management and clinical management of stroke risk factors.[5]

Historically, inpatient certified stroke programs were expected to prepare patients with stroke for discharge, educate the patient and family, and provide some preliminary anticipatory care.[6] However inpatient stroke programs often failed to take an active role in the coordination or provision of care post-discharge. In the past several years, we've witnessed a shift in responsibility and investment in stroke post-discharge care and a move towards a system-approach to care across multiple settings. This shift in responsibility may be partially driven by financial incentives and disincentives related to readmission and an overall move towards systems of healthcare.[7]

A recent study of over 2000 patients discharged with stroke in North Carolina found that continuity of care before, during, and after stroke was associated with care received and cost of care after stroke.[7] Accountable Care Organization (ACO) efforts and growth in hospital systems benefit from developing programs that serve patients across the care continuum. The services provided may range from coordinating post-discharge appointment times and post-discharge follow-up phone calls, to a dedicated clinician navigator who remains connected to the patient to coordinate care over time; these services may even include follow-up at a dedicated post-discharge stroke clinic managed by the stroke program. While these models are rapidly evolving, many stroke leaders still lack clarity regarding the responsibility of the certified stroke program to provide care post-discharge. Therefore, we discuss models of post-hospital stroke care that have emerged recently and provide stroke program leaders suggestions for evaluating their programmatic needs and possible solutions to meet those needs after hospital discharge.

Stroke Program Models of Post-Discharge Care

Stroke Navigation

Technology and patient expectations after the 2019-2021 pandemic have rapidly changed the delivery of ambulatory care. At hospital discharge, stroke programs report several newer models of care including care facilitation by a stroke clinician navigator, post-discharge stroke clinic follow up, and other transitional care models often supported by telemedicine. The concept of a patient navigator who helps patients navigate needed care across multiple providers and settings was first reported in the cancer patient population in the early 1990s.[8] Over the next two decades, the role became well established in cancer care with many positions held by nurses who were familiar with the disease process and care needed.[8] Patient navigators generally conduct an intake and then work with patients and families to help them navigate through the healthcare system while minimizing the need for referrals between primary care providers (PCP), specialists and the hospital.[8] These key clinicians may also help patients navigate needed testing before specialist appointments to maximize the utility of the visit. When setting up a patient navigator program, it is helpful to establish a comprehensive intake process to best understand the needs of the patient and family and to develop a comprehensive and holistic care plan.[8]

The navigation model is reported more recently in both the cardiac and stroke patient population and detailed in several articles in this issue of *Stroke Clinician*, although the role and responsibility of navigators varies widely between reported programs. One single center reported their experience with a nurse navigator team that followed patients treated with thrombolysis while hospitalized, and then connected with the patient at discharge to discuss the transition plan, follow-up appointments and any planned outpatient testing.[9] The nurse navigator then connected with the patient and family between days 3 and 7 after discharge to review the discharge summary, medications, and plans discussed at discharge. Any issues that the nurse navigator could not address during the follow-up call was referred to the discharging practitioners and/or quality officer. The study included 447 patients (287 before program implementation and 160 after) and the groups were well matched with only higher mechanical thrombectomy utilization and lower pre-admission oral anticoagulant use differing between the groups. The 30-day readmission rate was lower in the navigator implementation group (p=0.025) and the effect remained when accounting for confounding variables.[9]

Other programs have reported decreased stroke-related readmission in patients who received navigator services;[10,11] stroke navigation has also been shown to improve compliance with in-hospital stroke measures, and follow-up appointments.[11]

Transitional Stroke Clinics

Patients may have to wait for multiple weeks or even months to secure an appointment for outpatient follow-up with a stroke specialist such as a vascular neurologist or a neurosurgeon in many areas of the United States. While patients may be able to see their PCP faster, coordination of care between specialist stroke providers and PCPs after hospitalization may remain fragmented. Some inpatient programs have developed transitional stroke clinics that provide outpatient follow-up for one or several visits until the patient is able to have their care resumed by their PCP. Again, these clinics vary in their provider makeup, scope of care, and frequency of patient visits, but all tend to focus on finalizing the stroke evaluation, ensuring an appropriate management plan for stroke risk factors to minimize the risk of recurrent stroke, and identifying patients who are struggling after discharge for any reason. While this intervention has not been studied in large randomized controlled trials, individual programs report encouraging results from their clinics.

There are several reports of advanced practice registered nurse (APRN)-led clinics offering follow-up within 1-3 weeks post-discharge. One study found that patients seen in the APRN-led clinic were less likely to be readmitted within 30 days[12] while other studies found a trend towards less readmission that was not statistically significant, but did decrease time to follow-up and may have an impact on other measures such as satisfaction and implementation of best medical therapy.[13,14] Additional studies are needed to best understand who benefits from early and organized follow-up and the measures of success for such clinics. As technology advances, remote monitoring of physiologic health measures (e.g., blood pressure, weight, neurologic symptoms) may be incorporated into clinic follow-up.

Organized Transitional Stroke Care Programs and Technological Advances

Several recent reports of interprofessional and multi-intervention transitional stroke programs suggest that these endeavors may improve patient outcomes. A Canadian study reported the results of a randomized control trial testing an intensive program for stroke survivors discharged from hospital to community. Patients in the intervention arm received usual care plus 6 months of transitional stroke care. The transitional care stroke intervention (TCSI) was delivered virtually by a team and included navigation support, team care conferences and additional online resources for patients. These investigators enrolled 90 participants (34 intervention, 40 control). There was no difference in hospital readmission at 6 months, but improved physical functioning, self-management, and patient experience were noted.[15]

Gzesh and colleagues[16] reported the results of 3-years of an organized stroke bundle program at a Comprehensive Stroke Center (CSC) that combined inpatient protocolized patient management, transitional care protocols, an educational program, and daily rounding by a stroke nurse navigator focused on patient transitions for 90-days after discharge. The bundle approach was associated with a reduction in the number of patients admitted to a skilled nursing facility (SNF), decreased length of stay for those who were admitted to a SNF, and decreased 90-day hospital readmissions. The program also improved patient engagement.[16]

In studies and reports on post-hospital care, technology continues to rapidly alter the delivery of care. A recent study from Scandinavia included telerehabilitation as a key component of an early supported discharge program. They utilized technology such as wearable devices, tablets, virtual reality, and photos to provide rehabilitation services remotely. While it was a small exploratory study, the intervention was positively perceived by both patients and rehabilitation providers, and improved functional ability defined as meeting rehabilitation goals[17]. Cui and colleagues[18] also reported applying machine learning to predict patients at increased need for support at discharge. Wireless remote monitoring devices are already being used to obtain "at-home" physiologic parameters such as blood pressure, blood glucose, oxygen saturation and heart rhythm.[19] Some of these integrate seamlessly with electronic health records. As technology rapidly advances, its application to transitions of care in stroke programs will likely continue to evolve.

Models of Stroke Program Post-Discharge Care

Transitions of care for stroke patients are commonly addressed to ensure compliance with stroke certification standards, specifically in conjunction with patient-specific stroke education, a rehabilitation assessment, a post-discharge needs assessment, a 7-day follow-up phone call, and/or a 90-day disability assessment. Comparatively, the studies cited above utilized a significantly more intentional and robust approach for managing stroke patient transitions, finding that this improves patient outcomes, increases patient satisfaction, and reduces subsequent hospital admissions.

Perhaps the most significant questions stroke program leaders should be asking when it comes to stroke patient transitions of care are, "*How can we do this better? How can we improve care transitions and improve our stroke patient outcomes post-hospitalization? How can we better identify and address patient health needs that affect their individual outcomes, including their social determinants of health?*"

Answering all of these questions involves exploring development of a transitional care program that best fits individual stroke center patient population needs, alongside examination of organizational priorities, and program workflows.

Analyzing Your Stroke Patient Population's Needs

The first step in this process is defining stroke patients' post-discharge needs. To analyze this information, helpful information includes the number of stroke patients discharged to home, inpatient rehabilitation facilities, and skilled nursing facilities, readmissions rates (with particular attention to patients readmitted with preventable conditions), patient/family knowledge and understanding of discharge instructions, clinic follow-up rates, and patients who have a documented social or psychological need that wasn't addressed at discharge or followed-up after discharge. To obtain a comprehensive understanding of post-discharge needs, stroke leaders must rely on multiple sources of data and information; these include available post-hospital measures, discharge questionnaires, discharge notes, post-discharge follow-up phone calls, and patient satisfaction data. Important assumptions can also be made by examining transition work published by others. Quantifying this information helps define stroke patient needs and promotes prioritization of these needs in the context of the organization's capabilities. It also helps build context when considering new methods to incorporate into the stroke program that aim to address these needs.

Available Resources and Toolkits

There are toolkits developed by several sources that include documents, tips and resources for organizing a transitions of care program.[20,21] These are available online and include ideas for implementation, short- intermediate- and long-term goals, action steps, timelines, questionnaires, best practice performance metrics, and more. Stroke program leaders should also utilize resources such as a questionnaires to help identify post-discharge needs,[21-24] measures for gaps in knowledge faced by patients and caregivers,[21,24] and tools to measure social determinants of health (SDOH) in five domains (food insecurity, housing instability, transportation needs, utility difficulties, interpersonal safety).[21,22,25] Additionally, FindHelp.org is a free, online service, to search for community-based social service providers; this web-based service uses patient zip codes to provide a list of free or reduced cost services such as food, housing, care and transportation, and it can assist caregivers to find local food pantries, housing, utilities, financial, and phone services assistance programs.

Collecting Relevant Discharge Data

Just as in ongoing stroke program evaluation, stroke transitions in care programs require systematic review for improvement. A data-driven program design cannot be overemphasized. While data derived to support the planning process may be used for ongoing review, there are additional tools that may be useful. In addition to the toolkits mentioned above, the American Heart Association's *Get With The Guidelines Patient Management Tool* has a post-discharge data collection tab. Additionally, for those participating in the Paul Coverdell National Acute Stroke Program, a post-discharge measure set is available. Other post-discharge measure sets can be found online.[20,21]

Leadership Buy-In

The decision to pursue incorporation of new or more robust care transitions for stroke patients requires leadership and other stakeholder buy-in. Anticipated barriers include:

- Lack of administrative awareness and appreciation of post-discharge stroke care;
- Availability and cost of needed resources such as staff, clinic space, technology and electronic health record needs;
- Potential for territoriality and "turf" battles; and,
- Billing support.

Stroke program leaders must be prepared with data that illustrates the benefits of a transitional care program. Needed resources, whether new, realigned, or outsourced, must be justified to leadership using both quantitative and qualitative findings. The collection of data in the analysis phase may help give hospital leaders a clear picture of the needs a transition program will aim to fill, as well as the potential benefits.

Program leaders should build a story that clearly illustrates the transition problem and its downstream effects on readmissions, satisfaction, and emergency department visits. These findings should be further supported using published evidence that demonstrates the impact transition programs can have on improvement of patient and hospital outcomes. Ideally, a proposal should be presented that includes a schedule for reporting outcomes associated with the program on a regular basis. Anticipated operational efficiencies should be discussed and attempts to quantify new and retained patients in the health system should be undertaken. Because the cost of program development and implementation are likely to be an issue of administrative concern, program leaders should work with coding and reimbursement teams to evaluate opportunities for cost offsetting.

Depending on the structure of the program, transitional care management and chronic case management billing codes may be applicable (Medicare Learning Network: MLN 908628, 909188).[26,27] Additionally, beginning in 2024, the Centers for Medicare and Medicaid Services (CMS) agreed to reimburse hospitals and/or providers for caregiver training services, SDOH risk assessments, principal illness navigation services, and community health integration services (Medicare Learning Network: MLN 9201074).[25] Several of these services, such as collection of patient-level social risk factor information to link patients with community-based resources after discharge, are integral to robust stroke transitions of care programs and may now be billable to CMS when certain conditions are met.

Conclusions

Stroke programs are supported by clinicians that are uniquely qualified to create an innovative, robust stroke transitions program. The resources and publications outlined herein highlight newer models of post-discharge care and provide evidence to support the benefits of more timely and individualized post-discharge stroke care. Patients post-discharge needs are better served when health status and SDOH needs can be adequately assessed, and when attention is focused on health behaviors and factors affecting compliance with recommended recovery processes. When stroke clinicians have a better understanding of patient and caregiver needs and capabilities, and when the appropriate referrals and contacts are made to facilitate movement along the continuum of care, patient and stroke system outcomes will be improved. Building awareness among administrators and other key stakeholders in a manner that resonates with organizational goals will be key in gaining approval to move forward.

Author Affiliations

Dr. Sarah Livesay is the Associate Dean for Student Affairs at Rush University College of Nursing, Chicago, IL. sarah_l_livesay@rush.edu

Ms. Debbie Hill is a co-founder of Stroke Challenges, LLC and a partner in the Lombardi Hill Consulting Group, LLLP, Gainesville, Florida. dhill@lombardihill.com

References

1. Adeoye O, Nyström KV, Yavagal DR, et al. Recommendations for the Establishment of Stroke Systems of Care: A 2019 Update [published correction appears in Stroke. 2020 Apr;51(4):e70]. *Stroke*. 2019;50(7):e187-e210. doi:10.1161/STR.0000000000000173
2. Fowler K, Mayock P, Byrne E, Bennett K, Sexton E. "Coming home was a disaster, I didn't know what was going to happen": a qualitative study of survivors' and family members' experiences of navigating care post-stroke. *Disabil Rehabil*. Published online January 24, 2024. doi:10.1080/09638288.2024.2303368
3. Kilkenny, M. F., Dalli, L. L., Kim, J., Sundararajan, V., Andrew, N., Dewey, H. M., Johnston, T., Alif, S. M., Lindley, R. I., Jude, M., Blacker, D. (2019). Factors Associated With 90-Day Readmission After Stroke or Transient Ischemic Attack. *Stroke.* 2020; 51:571–578. https://doi.org/10.1161/STROKEAHA.119.026133
4. Rudberg AS, Berge E, Laska AC, et al. Stroke survivors' priorities for research related to life after stroke. *Top Stroke Rehabil*. 2021;28(2):153-158. doi:10.1080/10749357.2020.1789829
5. Bell, S., Kelly, H., Hennessy, E., Bermingham, M., O'Flynn, J. R., & Sahm, L. J. (2023). Healthcare professional perspectives on medication challenges in the post-stroke patient. *Frontiers in pharmacology*, *14*, 1266277. https://doi.org/10.3389/fphar.2023.1266277
6. Cameron JI, Tsoi C, Marsella A. Optimizing stroke systems of care by enhancing transitions across care environments. *Stroke*. 2008;39(9):2637-2643. doi:10.1161/STROKEAHA.107.501064
7. Hou Y, Trogdon JG, Freburger JK, et al. Association of Continuity of Care With Health Care Utilization and Expenditures Among Patients Discharged Home After Stroke or Transient Ischemic Attack. *Med Care*. 2024;62(4):270-276. doi:10.1097/MLR.0000000000001983
8. McMurray A, Cooper H. The nurse navigator: An evolving model of care. *Collegian*. 24(2):205-212. https://doi.org/10.1016/j.colegn.2016.01.002
9. Jun-O'Connell AH, Grigoriciuc E, Gulati A, et al. Stroke nurse navigator utilization reduces unplanned 30-day readmission in stroke patients treated with thrombolysis. *Front Neurol*. 2023;14:1205487. Published 2023 Jun 15. doi:10.3389/fneur.2023.1205487
10. Matmati, K., Matmati, N., Madison, S., Vogl, S., Bixler, B., Vogler, K., Dombovy, M., & Burke, C. (2022). A Stroke Transition Of Care Intervention With Stroke Nurse Navigator And Early Stroke Clinic Follow-up Reduces Readmissions For Stroke At 12 Months. *Stroke, 53* (Suppl_1) https://doi.org/10.1161/str.53.suppl_1.34
11. Deen, T., Terna, T., Kim, E., Leahy, B., & Fedder, W. (2018). The Impact of Stroke Nurse Navigation on Patient Compliance Postdischarge. *Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses*, *43*(2), 65–72. https://doi.org/10.1097/RNJ.0000000000000086
12. McClain JV 4th, Chance EA. The Advanced Practice Nurse Will See You Now: Impact of

a Transitional Care Clinic on Hospital Readmissions in Stroke Survivors. *J Nurs Care Qual*. 2020;35(2):147-152. doi:10.1097/NCQ.0000000000000414
13. Kao A, Lanford J, Wong LK, Ranta A. Do clinical nurse specialist led stroke follow-up clinics reduce post-stroke hospital readmissions and recurrent vascular events?. *Intern Med J*. 2020;50(10):1202-1207. doi:10.1111/imj.14707
14. Mitchell E, Reynolds SS, Mower-Wade D, Raser-Schramm J, Granger BB. Implementation of an Advanced Practice Registered Nurse-Led Clinic to Improve Follow-up Care for Post-Ischemic Stroke Patients. *J Neurosci Nurs*. 2022;54(5):193-198. doi:10.1097/JNN.0000000000000670
15. Markle-Reid, M., Fisher, K., Walker, K. M., Beauchamp, M., Cameron, J. I., Dayler, D., Fleck, R., Gafni, A., Ganann, R., Hajas, K., Koetsier, B., Mahony, R., Pollard, C., Prescott, J., Rooke, T., & Whitmore, C. (2023). The stroke transitional care intervention for older adults with stroke and multimorbidity: a multisite pragmatic randomized controlled trial. *BMC geriatrics*, *23*(1), 687. https://doi.org/10.1186/s12877-023-04403-1
16. Gzesh D, Murphy DA, Peiritsch H, MacCracken T. Benefit of a Stroke Management Program. *Popul Health Manag*. 2020;23(6):482-486. doi:10.1089/pop.2019.0123
17. Ouédraogo, F., Auger, L. P., Moreau, E., Côté, O., Guerrera, R., Rochette, A., & Kairy, D. (2024). Acceptability of Telerehabilitation: Experiences and Perceptions by Individuals with Stroke and Caregivers in an Early Supported Discharge Program. *Healthcare (Basel, Switzerland)*, *12*(3), 365. https://doi.org/10.3390/healthcare12030365
18. Cui Y, Xiang L, Zhao P, et al. Machine learning decision support model for discharge planning in stroke patients. *J Clin Nurs*. Published online February 15, 2024. doi:10.1111/jocn.16999
19. Jeong JW, Lee W, Kim YJ. A Real-Time Wearable Physiological Monitoring System for Home-Based Healthcare Applications. *Sensors (Basel)*. 2021;22(1):104. Published 2021 Dec 24. doi:10.3390/s22010104
20. Minnesota Department of Health Stroke Program. (2019, February 20). Minnesota Department of Health. Retrieved from Minnesota Stroke Program Resources: https://www.health.state.mn.us/diseases/cardiovascular/documents/toctoolkit.pdf
21. Arkansas Department of Health. (2022, June20). Arkansas Department of Health. Retrieved from Arkansas Stroke Program Resources: https://www.healthy.arkansas.gov/images/uploads/pdf/AR_Stroke_Transition_of_Care_Toolkit.pdf
22. Agency for Healthcare Research and Quality. (2014, August). Hospital Guide to Reducing Medicaid Readmissions. Retrieved from Agency for Healthcare Research and Quality: https://www.ahrq.gov/sites/default/files/publications/files/medread-tools.pdf
23. Amatya B., Elmalik A., Lee S.Y., Song K., Galea M., Khan F. A process evaluation of patient care needs using the post-stroke checklist: A prospective study. *Journal of Rehabilitation Medicine*. 2022;54. doi:10.2340/jrm.v53.349
24. Bajorek, S. A., McElroy, V., (2020, March 25). Discharge Planning and Transitions of Care. Retrieved from Agency for Healthcare Research and Quality: https://psnet.ahrq.gov/primer/discharge-planning-and-transitions-care
25. Centers for Medicare and Medicaid Services (CMS) Medicare Learning Network: MLN 9201074 (2024, January). Retrieved from Centers for Medicare and Medicaid Services: https://www.cms.gov/files/document/mln9201074-health-equity-services-2024-physician-fee-schedule-final-rule.pdf-0
26. Centers for Medicare and Medicaid Services (CMS) Medicare Learning Network: MLN 908628 (2023, May). Retrieved from Centers for Medicare and Medicaid Services: https://www.cms.gov/files/document/mln908628-transitional-care-management-services.pdf
27. Centers for Medicare and Medicaid Services (CMS) Medicare Learning Network: MLN 909188 (2022, September). Retrieved from Centers for Medicare and Medicaid Services: https://www.cms.gov/outreach-and-education/medicare-learning-network-mln/mlnproducts/downloads/chroniccaremanagement.pdf

Blood Pressure: The History and Development of Monitoring Modalities

Desiree M. Cihelka, PhD(c), MSN, RN, ARNP-C, ANVP-BC[1]

Abstract

Background

Blood pressure (BP) is one of the most frequently measured and monitored physiologic vital signs by all stroke clinicians, yet data suggest that only 1 out of 5 clinicians applies evidence-based methods for BP monitoring.

Methods

An exhaustive review of the literature was conducted and assembled to provide a historical clinical account of BP monitoring modalities and related evidence-based clinical methods.

Results

Evidence-based clinical methods are described for use of manual sphygmomanometry, noninvasive oscillometric automatic BP (NIBP) monitors, and arterial lines. Implications for practice are discussed in relation to provision of acute and critical care of ischemic and hemorrhagic stroke patients.

Conclusion

Use of evidence-based BP monitoring methods ensures accurate management of highly vulnerable stroke patients. Knowledge of the history of BP monitoring, along with the benefits and limitations of different measurement methods enables accuracy in BP treatment, benefitting stroke patient outcomes.

Key words: Blood pressure; arterial pressure; mean arterial pressure; clinical monitoring; vital signs; acute stroke.

INTRODUCTION

Blood Pressure (BP) is one of the most important signs of human life. It reflects not just the cardiovascular health of an individual but, also is a vital sign of perfusion to organs and cells throughout the body.[1] Because the brain is the most energy-demanding organ in the body, it is the most important and "particular" organ to perfuse.[2] The healthy adult brain receives an estimated 15-20% of the cardiac output in resting conditions.[2] Autoregulation ensures that the brain maintains a delicate balance of cerebral perfusion and neurovascular coupling for the high metabolic demands of oxygen and glucose.[3] Neurons are unique because they do not regenerate nor survive without blood flow to deliver oxygen.[4] Correct measurement of blood pressure is essential to the treatment and management of both chronic diseases and acute illness and can profoundly affect patient outcomes in patients with stroke.

Simply defined, BP is the force of blood pushing through and against arterial walls with each heartbeat.[5] Most commonly, the BP measurements used clinically are systole and diastole, followed by mean arterial pressure (MAP).[6] Systolic blood pressure (SBP) is the pressure caused by the heart contracting and forcing outward blood flow, whereas diastolic blood pressure (DBP) is the pressure during heart relaxation while the left ventricle fills with blood. MAP is the average arterial pressure that pulses through the vasculature in one cardiac cycle.[7]

The importance of SBP/DBP goals in adults has been well established, and both are used for hypertension management in primary and secondary prevention of cardiovascular and cerebrovascular disease.[5,6,8] In patients with systemic blood flow limitations, as in trauma or types of shock, MAP becomes an increasingly valuable parameter for assessing tissue and organ perfusion.[9] MAP is influenced by cardiac output and systemic vascular resistance, making it ideal to reflect overall systemic organ perfusion.[7] Maintaining a MAP that is too low may result in inadequate perfusion and subsequent organ failure, with catastrophic outcomes; conversely, a MAP that is too high can strain the heart muscle and rupture small perforating arterioles.[10,9] The parameters for MAP in cardiac diseases are tailored to the vascular dynamics of the patient.[10,11,12] However, goals for MAP remain understudied in neurovascular diseases. In fact, ischemic and hemorrhagic stroke guidelines are totally silent on MAP goals for both acute and post-acute care.

THE HISTORY OF BLOOD PRESSURE MEASUREMENT

There are several methods used in the clinical setting to measure BP. Non-invasive measurements utilizing manual sphygmomanometer as well as automated intermittent oscillometric devices are most common across the world and are used in nearly all clinical settings. Invasive monitoring is used in select patient groups requiring critical care services for severe illness, injury, frequent blood draws, or in intraoperative monitoring.

While the first clinical BP measurement was reported in 1856 by the surgeon Faivre, who connected an artery to a mercury manometer to obtain direct readings during an operation, the earliest crude observations of pulse pressure in horses were published by Hales in the middle of the eighteenth century.[13] Hales' methods resulted in the death of each horse, making them unsuitable for studying human BP. It was not until the nineteenth century, nearly 100 years after Hales' work, that the physician-physicist Poiseuille published his work on resistance in the cardiovascular system, pushing innovation forward. Poiseuille's 1882 doctoral dissertation was published on the use of a mercury manometer to measure arterial blood pressure.[14] After some modifications to Poiseuille's equipment, the remaining two decades of the nineteenth century offered methods equipped with graphic recordings. In 1855, Vierordt's sphygmograph emerged which provided the first attempt at non-invasive methods of BP monitoring.[14]

NON-INVASIVE BP METHODS

Early non-invasive BP measurement methods required obliteration of the radial pulse by a cumbersome weight attached to a lever on a sphygmograph; this did not fare well in clinical practice. Finally, in 1881, Von Basch presented a more accurate, portable apparatus to investigate the first hemodynamic pathologies with a mercury bulb and rubber bag of water; later, an air-filled bladder replaced the water for arterial compression.[14]

Manual Sphygmomanometer

After gradual improvement in BP measurement devices, Riva-Rocci's mercury sphygmomanometer method emerged in 1896 and is what present-day monitoring is based upon.[15] His inflatable cuff method compressed the brachial artery from all sides equally and allowed for observation of oscillations associated with SBP. Interestingly, it was Harvey Cushing, the American neurosurgeon, who brought this method to the US in 1901 from Italy, marking the beginning of modern non-invasive BP measurement.[16]

Riva-Rocci's mercury sphygmomanometer method worked well for SBP, and ultimately, assumptions about DBP arose in relation to different compression pressures. However, Korotkoff's technique offered a crucial advancement in BP measurement by using a stethoscope to listen for the sounds of blood flowing through the artery, ultimately providing more valid and reliable measures of both SBP and DBP.[17] The Korotkoff auscultatory method involves compression of the brachial artery and auscultation over the antecubital fossa to determine the SBP and DBP. Although true MAP is obtained using invasive monitoring, it can also be calculated based on a physiologically sound formula that uses SBP and DBP obtained during auscultation. The MAP calculation was developed from the knowledge that diastole persists for 2/3 and systole for 1/3 of each cardiac cycle; therefore the calculation uses a third of the pulse pressure added to the DBP.[1,7] $MAP = (SBP - DBP)/3 + DBP$.[1,7] This simple calculation is still used today to determine MAP from manually-derived SBP and DBP.

Korotkoff's technique has limitations, such as artifacts due to movement and challenging physiologic variations of Korotkoff sound patterns or poor signals that can be difficult to hear by the clinician.[18] Korotkoff's sounds can also be hard to hear in morbidly obese patients or those with rigid arteries due to systemic atherosclerotic disease or simply advanced age.[1] Additionally, auscultation is often difficult when patients have severe hypotension or organ failure, making Korotkoff sounds difficult to distinguish due to fluctuations in intra-arterial pressure.

The American Heart Association (AHA) Scientific Statement for Recommendations for Blood Pressure Measurement in Humans and Experimental Animals describes the proper cuff and sphygmomanometer technique.[19] First, the examiner palpates the brachial artery in the antecubital fossa and places the bladder of the cuff midline on the patient's upper arm just above the brachial arterial pulsation, with the lower end of the cuff 2 to 3 cm above the antecubital fossa, leaving room for the stethoscope. Artifact can be generated by noise in the room, clinicians or the patient speaking, and if the stethoscope touches the cuff.[6] The cuff is first inflated without auscultation until the pulse is no longer palpable; this indicates suspected systolic pressure.[6] The cuff is further inflated to at least 30 mmHg above the point at which the radial pulse disappeared; auscultation occurs during slow deflation of the cuff.[20] The rate of deflation has a significant effect on blood pressure determination.[21] Deflation rates > 2 mm per second can lead to a significant underestimation of SBP and an overestimation of DBP.[19] Korotkoff sounds accompany the return of pulsatile blood flow as the cuff deflates, with phase 1 sounds indicating SBP and phase 5 sounds indicating DBP. A full 5 minutes should occur between re-inflation of the BP cuff to allow for arm revascularization.

Automatic Oscillometric Methods

Until the 1980s, the manual sphygmomanometer was the only means of obtaining a non-invasive BP. The evolution of computers and the need for timely, non-invasive BP measurement led to the first automatic oscillometric BP (NIBP) device patent by Ramsey, III (Johnson & Johnson, assignee), with approval for use in 1982 (Device Non-invasive Measurement of Arterial Pressure [DINAMAP]).[22] These early devices only displayed MAP, but this quickly evolved to devices that displayed algorithmically determined SBP and DBP, which gave way to later generations of the more sophisticated devices used today.[1,22,23] NIBP devices have become the standard of care within American and most high and middle income healthcare settings, with many companies manufacturing bedside instruments and software packages.

Digital NIBP devices do not measure SBP and DBP. Instead, these devices use software to algorithmically assign an estimate of SBP and DBP from the measurement of MAP.[23,24] The endpoint for DBP is indistinct since cuff pressure oscillations continue when cuff pressure falls beneath diastolic blood pressure.[23,25] MAP is determined by measuring cuff pressure oscillations as the cuff pressure is reduced by discrete increments.[26] The heartbeat-induced pulse volume changes small oscillations of intra-cuff pressure, which are sensed by the cuff and measured by a pressure transducer, allowing incremental data to be tested for artifact and averaged rather than to allow for continuous artifact-rejection.[23] MAP is selected as the lowest cuff pressure at maximum oscillation amplitude.[24] MAP correlates directly with maximum oscillations and is accepted as the most accurate value derived from NIBP devices.[24] NIBP devices are not recommended for use in patients with arrythmias that impact stroke volume, such as atrial fibrillation,[23,24,27] because of an erratic MAP with stroke volume variation that results in inaccurate device performance. Unfortunately, very few interprofessional clinicians are aware of this fact, leading to continued use of NIBP in patients with atrial fibrillation which leads to highly invalid and unreliable BP measurement. Many clinicians also fail to document MAP when documenting vital signs from an NIBP device despite the fact that MAP is the most accurate pressure measured by NIBP. Although the MAP formula could be applied, interestingly, there is no agreement between the MAP generated from an NIBP and the MAP calculated from NIBP-produced SBP and DBP; this fact clearly demonstrates the proprietary, unknown nature of the formulas used by these devices to produce SBP and DBP variables from the NIBP estimated MAP.

Each NIBP manufacturer uses different computer algorithms and software for testing and validation procedures to estimate MAP, SBP, and DBP data, and these vary significantly from one device to another.[28] These proprietary patented algorithms for SBP/DBP present a scientific dilemma as they cannot be easily validated by external authorities.[21] To ensure the accuracy of data from machines and the validity of devices, in 1987, the American National Standards Institute (ANSI) and the United States Association for the Advancement of Medical Instrumentation (AAMI) published the first joint standards and recommended practices for automated non-invasive oscillometric devices.[28] Updates have been made in subsequent years from ANSI/AAMI and others from around the world through protocol publication by the International Organization of Standardization (ISO) for device validation.[28] The most recent update from ANSI/AAMI/ISO states that a device is considered acceptable if its estimated probability of a tolerable error (< 10 mm Hg) is at least 85%;[29,28] this means that there should be no more than a 10 mm Hg difference in BP readings in at least 85% of patients tested. While statistically, this tolerable error may be acceptable, clinically, a 10 mm Hg difference in BP readings can lead to potentially harmful therapeutic interventions or missed opportunities to implement critical treatments. For example, failure to lower BP in an intravenous thrombolysis patient because the reading was 172 mm Hg SBP, while the "true" reading was 182 mm Hg, may increase the risk for a symptomatic intracerebral hemorrhage (sICH).

The proper cuff size is paramount for any "cuff-based" non-invasive method of BP measurement, and inappropriate cuff sizing constitutes the most common form of measurement error. The "ideal" cuff should have a bladder length of 80% and a width of at least 40% of the arm circumference (a length-to-width ratio of 2:1).[19] However, in patients with morbid obesity, the very large arm circumference combined with a short upper arm length often results in geometry that cannot be correctly cuffed.[21] Difficulty with properly applying BP cuffs in obese patients often causes clinicians to resort to the use of a thigh cuff placed on the forearm, with Korotkoff sounds auscultated over the radial artery by the wrist; unfortunately, this method may overestimate SBP.[30,19] Even when brachial cuffs are used, on average, NIBP tends to overestimate BP during hypotension and underestimate BP during hypertension, demonstrating significant measurement bias.[30] In comparison, invasive BP measurement with an arterial catheter can detect nearly twice as many episodes of hypotension as NIBP taken with a brachial cuff.[31]

INVASIVE BP MONITORING

Invasive arterial pressure monitoring by arterial lines, or "A-lines," constitutes the gold standard for BP measurement; however, it is used most commonly in critical care and intraoperative settings.[7,32] Unlike discontinuous cuff measurements, the A-line offers a direct and continuous measurement method that gives more accurate and frequent detection of alterations in BP for the most critical patients at high risk of complications. Precise measurements in the most vulnerable patient populations can make a significant difference, as observed measurement differences are clinically significant because they trigger a change in treatment in as many as 20% of critical care patients.[33] Indications for A-lines are as follows: [34]

- Patients who require timely adjustments for sudden changes in hemodynamics, where interval BP measurements may be unsafe.
- Patients being treated with vasoactive medications requiring safe and precise titration of medication to the desired blood pressure effect.
- Surgical patients at increased risk of morbidities or mortality, either because of preexisting comorbidities (cardiac, pulmonary, anemia, etc.) or because of more complicated procedures. These include but are not limited to neurosurgical and cardiopulmonary surgeries and procedures in which a large volume of blood loss is anticipated.
- Patients who require frequent lab draws. The A-line allows clinicians easy blood sampling access without repeat venipuncture, thereby decreasing discomfort and infection risks. Additionally, frequent arterial blood gas measurements can be obtained by A-line to guide adjustments in mechanical ventilation settings; hemoglobin, and hematocrit can also be monitored in relation to blood loss or transfusion, and both electrolyte imbalance/correction,

and patients' responsiveness to fluid resuscitation can be monitored.

Much like Faivre's original technique, modern arterial pressure monitoring is accomplished by cannulating an artery to measure real-time BP changes. Generally, a peripheral artery puncture site, such as the radial artery, is chosen for ease of access. A short catheter is placed inside the artery's inner wall and connected to a pressure transducer. The pressure transducer interface changes the mechanical pressure into SBP, DBP, and MAP measures for use in clinical practice.[35] The phlebostatic axis corresponds to the height of the patient's right atrium, which is the hydrostatic pressure reference level, and the transducer must be kept at this level to ensure accurate pressure measurements.[34] Most high income countries utilize transducers that are disposable and calibrated by the manufacturer; these are filled with a saline interface and zeroed at the phlebostatic axis. Accuracy of disposable transducers must be less than +/- 3% or +/- 3mm Hg in accordance with the published ISO/ANSI standards.[36,37]

Transducers are prone to drift and must be re-zeroed at regular intervals.[33] To accurately measure BP using an A-line, the clinician must level and zero the transducer and check the quality of the resulting BP waveform.[26] The morphology of the BP waveform changes when the BP wave moves from the aorta to a more peripheral artery.[38] Correct leveling of the transducer is crucially important, as a height difference between the transducer level and the level of the cannulated vessel of only 10 cm results in a pressure difference of 7.5 mmHg because of the hydrostatic pressure gradient.[38] Zeroing is considered successful when the fluid-filled transducer interface shows a pressure line at 0 mmHg with the stopcock turned off to the patient's artery; the stopcock is then returned to a position that opens the interface between the patient's artery and the transducer to resume monitoring. The optimal quality of the arterial waveform is fundamental to correct BP and measurements, as well as hemodynamic variable measurements.[39]

There are risks of inaccuracy during leveling, zeroing, and transducing A-lines caused by human error. The natural frequency of the measurement must exceed the frequency range of the arterial pulse; this extends to 20-25 Hz for accurate measurement of maximum pressure during left ventricular isovolumetric contraction (dP/dtmax), which is reflected by the systolic upstroke on the arterial waveform.[40] The A-line system requires critical dampening to prevent overshoot of measurements. In theory, proper dampening ensures the amplitude is accurately measured within 2% in up to two-thirds of the natural frequency, with distortion rates no more than 6% of the natural frequency.[33] Over-dampening results in under-reading of SBP and dP/dtmax, while over-reading the DBP. Additionally, when under-dampening occurs, the SBP average can be overestimated.[40] Some studies have shown that SBP overestimation of 2.6±1.9 (mean±SD) mm Hg can occur even in adequately dampened systems.[33] Clinicians should understand the importance of the shape of arterial BP waveforms due to dampening and resonance phenomena. The BP waveform is a complex amalgamation of antegrade and retrograde pressure waves. It is affected by vascular compliance (e.g., atherosclerosis), distance of the transducer from the left ventricle, and the 3D structure of the vascular tree.[41] MAP is considered the most accurate variable produced by A-line since it is less affected by dampening and resonance than SBP and DBP.[39]

Mean arterial pressure is the product of cardiac output (CO), systemic vascular resistance (SVR), and venous volume (as reflected by central venous pressure [CVP]), where CVP is typically a value of 0 mm Hg. However, SVR is strictly a calculated variable that cannot be measured directly and requires a known MAP to calculate (SVR = 80 x [MAP-CVP]/CO); therefore, the simplified MAP equation of one-third the pulse pressure added to the DBP is used in clinical practice.[42] But the relationship between CO, SVR, and MAP is important to acknowledge as the bedrock for understanding systemic hemodynamics, in that a decrease in CO produces an increase in SVR in an attempt to ensure the stability of MAP. This inverse relationship between CO and SVR is essential to understand; in fact, under non-septic conditions, severe drops in CO that lead to a decrease in MAP are classically still accompanied by markedly elevated SVR. DBP can be used clinically to reflect changes in SVR since SVR cannot be measured directly; for example, abnormally low DBP reflects extremely low SVR, as seen in conditions such as sepsis, whereas abnormally high DBP reflects increases in SVR which may occur during severe hypovolemia, early cardiogenic shock, or in combination with elevation in SBP during states of acute downstream increased resistance to blood flow resulting in sympathomimetic activation (e.g. increased intracranial pressure, vascular stenoses or occlusions).

Although non-invasive continuous BP monitoring has fewer complications than arterial cannulation, it has not replaced A-line monitoring as the standard of care in high-risk patients. For example, patients with hemorrhagic stroke are at high risk for mortality and morbidity, making them more likely to require A-lines. According to the AHA/ASA guidelines, these patients should be admitted to critical care or specialized stroke units and managed by specialty-trained vascular neurologists and neurocritical care clinicians.[43] While not all hemorrhages are severe nor require mechanical ventilation, hemorrhagic stroke patients very commonly require vasoactive medications that must be titrated. Of paramount significance, most current therapeutic interventions for intracerebral hemorrhage are based upon the assumption of accurate BP measurements, making A-lines the most optimal choice despite concerns for infection tied to invasive monitoring.

COMPARISON STUDIES BETWEEN BLOOD PRESSURE METHODS

Clinicians and researchers must ensure that valid and reliable measures of BP are obtained. Efforts have been made to determine factors associated with different BP measurement devices, most of which have been done on healthy individuals, making it difficult to determine consensus regarding chronically ill or acutely ill individuals. The AHA states there is little to no evidence regarding validation of BP measurements obtained in the acute care setting[6,1] which is unsettling.

There are limited comparison studies for BP methods in specific disease processes and patient populations, surprisingly even in patients with hypertension diagnoses. Epidemiologists who study the prevalence of hypertension conducted comparison studies between NIBP and mercury sphygmomanometer and found that despite minor differences in mean values, the agreement and reliability were deemed not good enough to adopt in epidemiologic surveys of hypertension because the “true” prevalence of hypertension was determined to be significantly underestimated.[44]

Comparison studies in critically ill patients can be especially challenging because of compromised vascular systems and less than favorable critical care unit conditions. Additionally, some studies have shown that NIBP measurements are inaccurate in critically ill patients.[35,45] For example, a critical care study using the AAMI protocol compared 150 pairs of measurements using three different brands of NIBP devices, versus the average of 1 minute of intra-arterial reference pressures, found that only MAP was accurately measured by all, one device measured DBP accurately, and there were no devices that measured SBP accurately.[45] Another study with 852 patients utilized regression-based Bland-Altman technique to evaluate differences of 27,022 concurrently measured A-line/NIBP sample pairs, found that clinically significant discrepancies existed between the two, especially during hypotension and suggested that MAP rather than SBP is the preferred metric to guide ICU therapy.[35]

Another critical care study looking at 3 different BP methods (oscillometric, auscultated, and palpated) compared to A-line that included 44 patients with common diagnoses known to have unstable hemodynamics requiring A-line placement (septic shock 47.7%; stroke 13.6%; increased intracranial pressure 13.6%).[46] The data from this study showed that palpated SBP values had a clinically significant difference compared to A-lines. There was no significant statistical difference between the oscillometric and auscultated SBP readings, but NIBPs were found to significantly under-estimate A-line measurements. Findings also suggested that auscultated and oscillometric BPs may provide similar measurements.[46]

Recently, comparison work on the agreement between manual and NIBP measurements of SBP, DBP, and MAP in ischemic stroke patients treated with intravenous thrombolysis with analysis using Bland-Altman technique and Lin Concordance correlation coefficient found that NIBP devices produce significantly different BP measures than manual sphygmomanometry auscultated BP.[47] The differences in SBP, DBP, and MAP between NIBP and sphygmomanometry failed to reach AAMI guideline recommendations.[47] These data are concerning since the BP thresholds used for BP lowering to reduce the risk for sICH after thrombolysis were derived from manual sphygmomanometry methods in the NINDS rt-PA Stroke Study, because of a concern that bruising would occur from NIBP cuffs after thrombolytic treatment. Currently, a similar study is underway in patients with hypertensive intracerebral hemorrhage. Collectively, these two studies may create a need to rethink the widespread use of NIBP, and/or the neurovascular community's use of SBP values instead of use of MAP when NIBP devices are utilized.

Current comparison research has led to no consensus as to which device is "best" to use in the acute care setting or with any cohort of critically ill patients such as patients with stroke. There is a vital need to better understand the agreement of BP methods and how this affects blood pressure management. Furthermore, it is not without consequences when there are discrepancies between devices.

IMPLICATIONS FOR PRACTICE

This article identifies many key implications for practice that are tied to the need for accurate BP monitoring. The physiology of cerebral blood flow (CBF) and BP are closely intertwined. Optimal perfusion to the brain is driven by autoregulation, which, under normal conditions, allows for constant blood flow to the brain despite variations in arterial pressure. Intact autoregulatory processes illustrate the relationship between MAP and mean CBF[48]; active regulation of brain arterial vasoconstriction and dilation occur to maintain a MAP between 60 to 150 mm Hg.[3]

Overall cerebral perfusion can be estimated by calculating cerebral perfusion pressure (CPP), which is the product of MAP minus intracranial pressure (ICP). However, this formula does not account for discrete CPP within the boundaries of local hemodynamically challenged vascular regions.[49,50] In fact, within local regions deprived of sufficient arterial blood flow due to hematoma compression in ICH, vasospasm in aneurysmal subarachnoid hemorrhage (aSAH), or arterial occlusion in ischemic stroke, all autoregulatory mechanisms are lost since they are dependent on intracellular adenosine triphosphate reserves produced by oxygen and glucose. Poor perfusion with absence of autoregulatory processes results in passive vasomotor exhaustion of arterial vessels along with accumulation of lactic acidosis. Autoregulatory failure makes perfusion fully dependent on BP within ischemic regions to ensure some degree of forward arterial flow through affected vasculature.

Sympathomimetic activation[51,52] from arterial occlusion, hematoma expansion, and/or development of increased ICP can be contributors to elevated BP in stroke patients.[53,54] Large hematoma volume or large territory ischemic stroke in patients with less brain atrophy, or stroke occurring in specific territories that may compress the ventricular system or brainstem (e.g. cerebellum) all contribute to whether ICP will increase after a stroke. Clinicians must fully understand factors associated with BP elevation to ensure appropriate patient management and optimal perfusion when increased ICP occurs. However, there are additional considerations in stroke patients that are not tied to ICP when considering optimal BP monitoring and management.

In ICH, the primary danger of precipitous BP elevation is worsening of secondary brain injury with the extension of bleeding into the ventricular and subarachnoid spaces, resulting in worsening neurologic disability.[55,56] While it is clear that BP elevation and hematoma expansion are related, it still remains unclear whether the hematoma expansion causes BP elevation, or whether the BP elevation causes hematoma expansion; in fact, it may be that this differs on a patient to patient basis. While the current ICH guidelines recommend that BP should be controlled as quickly as possible (within two hours of ICH onset, with BP at goal within one hour),[43] it is also important to note that sharp spikes and large variability in BP should also be avoided. Secondary analyses of data suggest that smooth and sustained control that limits variability may reduce hematoma expansion and produce better functional outcomes,[52] although at this time, this finding is hypothesis generating only. Despite this, the early effects of BP lowering should be evaluated in the first 24 hours by repeat non-contrast CT of the brain to assess hematoma growth, as well as frequent neurologic exams using the National Institutes of Health Stroke Scale (NIHSS)[57] to detect early neurologic deterioration.

Guidelines supporting BP management in ischemic stroke are supported by better evidence for BP lowering, despite the arbitrary selection of the BP values that originated with the NINDS rtPA Stroke Study.[58,59] Elevated risk for sICH has been documented with excessive BP levels[59] ensuring widespread adoption of BP thresholds of 180/105 mm Hg. Similarly, guidelines supporting management of aneurysmal subarachnoid hemorrhage call for control of BP to less than 140/90 mm Hg in the period before aneurysm occlusion,[60] although use of permissive hypertension and induced hypertension may also support the management of patients with arterial vasospasm by augmenting brain perfusion following aneurysm occlusion.[60]

Most compelling is the fact that guidelines are silent regarding goals for MAP, despite the knowledge that MAP significantly affects CBF,[48,49,50,61] and despite the widespread use of NIBP monitoring which only directly measures MAP and algorithmically assigns systolic and diastolic pressures. CBF is known to decrease in the setting of both ischemic and hemorrhagic stroke,[62,63,64] yet few clinicians document or even consider MAP values in the management of acute stroke patients.

CONCLUSIONS

Although BP is among the most commonly monitored vital signs, the methods supporting accurate BP monitoring are often overlooked in everyday practice. Additionally, given the widespread use of NIBP devices and the importance of MAP values, further exploration is paramount to increase understanding of critical MAP thresholds that should support stroke patient management. Clinicians are encouraged to document and examine MAP values as they manage both ischemic and hemorrhagic stroke patients to further knowledge of this key parameter in relation to stroke patient outcomes.

Author Affiliations

PhD Candidate, University of Tennessee Health Science Center, Memphis, TN.

Corresponding Author

Desiree M. Cihelka
Dmetzge1@uthsc.edu

Conflict of interest statement

The author reports no conflicts.

Funding

The author reports no grant support for this work.

REFERENCES

1. Muntner P, Shimbo D, Carey RM, et al. Measurement of Blood Pressure in Humans: A Scientific Statement From the American Heart Association. *Hypertension*. 2019;73(5):e35-e66. doi:10.1161/HYP.0000000000000087

2. Xing CY, Tarumi T, Liu J, et al. Distribution of cardiac output to the brain across the adult lifespan. *J Cereb Blood Flow Metab*. 2017;37(8):2848-2856. doi:10.1177/0271678X16676826

3. Paulson OB, Strandgaard S, Edvinsson L. Cerebral autoregulation. *Cerebrovasc Brain Metab Rev*. 1990;2(2):161-192.

4. Brain Basics: The Life and Death of a Neuron | National Institute of Neurological Disorders and Stroke. Accessed January 24, 2023. https://www.ninds.nih.gov/health-information/public-education/brain-basics/brain-basics-life-and-death-neuron

5. High Blood Pressure www.heart.org. Accessed January 24, 2023. https://www.heart.org/en/health-topics/high-blood-pressure

6. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2018;71(19):e127-e248. doi:10.1016/j.jacc.2017.11.006

7. DeMers D, Wachs D. Physiology, Mean Arterial Pressure. In: *StatPearls*. StatPearls Publishing; 2022. Accessed January 24, 2023. http://www.ncbi.nlm.nih.gov/books/NBK538226/

8. Gaciong Z, Siński M, Lewandowski J. Blood Pressure Control and Primary Prevention of Stroke: Summary of the Recent Clinical Trial Data and Meta-Analyses. *Curr Hypertens Rep*. 2013;15(6):559-574. doi:10.1007/s11906-013-0401-0

9. Morrison CA, Carrick MM, Norman MA, et al. Hypotensive resuscitation strategy reduces transfusion requirements and severe postoperative coagulopathy in trauma patients with hemorrhagic shock: preliminary results of a randomized controlled trial. *J Trauma*. 2011;70(3):652-663. doi:10.1097/TA.0b013e31820e77ea

10. Association of Fatal and Nonfatal Cardiovascular Outcomes With 24-Hour Mean Arterial Pressure. doi:10.1161/HYPERTENSIONAHA.120.14929

11. Ono M, Brady K, Easley RB, et al. Duration and magnitude of blood pressure below cerebral autoregulation threshold during cardiopulmonary bypass is associated with major morbidity and operative mortality. *J Thorac Cardiovasc Surg*. 2014;147(1):483-489. doi:10.1016/j.jtcvs.2013.07.069

12. Kiabi FH, Soleimani A, Habibi MR. Neuroprotective Effect of Low Mean Arterial Pressure on Postoperative Cognitive Deficit Attenuated by Prolonged Coronary Artery Bypass Time: A Meta-Analysis. *Braz J Cardiovasc Surg*. 2019;34(6):739-748. doi:10.21470/1678-9741-2018-0263

13. Tsyrlin VA, Pliss MG, Kuzmenko NV. The history of blood pressure measurement: from Hales to our days. *Arter Gipertenz Arter Hypertens*. 2016;22(2):144-152. doi:10.18705/1607-419X-2016-22-2-144-152

14. Booth J. A Short History of Blood Pressure Measurement. Published online November 1977.

15. Roguin A. Scipione Riva-Rocci and the men behind the mercury sphygmomanometer: The History Behind the Mercury Sphygmomanometer. *Int J Clin Pract*. 2005;60(1):73-79. doi:10.1111/j.1742-1241.2005.00548.x

16. Doyle NM, Doyle JF, Walter EJ. The life and work of Harvey Cushing 1869–1939: A pioneer of neurosurgery. *J Intensive Care Soc*. 2017;18(2):157-158. doi:10.1177/1751143716673076

17. Estañol B, Delgado G, Borgstein J. Korotkoff Sounds - The Improbable also Occurs. *Arq Bras Cardiol*. 2013;101(5):e99-e100. doi:10.5935/abc.20130217

18. Bonnafoux P. Auscultatory and oscillometric methods of ambulatory blood pressure monitoring, advantages and limits: a technical point of view. *Blood Press Monit*. 1996;1(3):181-185.

19. Pickering TG, Hall JE, Appel LJ, et al. Recommendations for Blood Pressure Measurement in Humans and Experimental Animals. *Hypertension*. 2005;45(1):142-161. doi:10.1161/01.HYP.0000150859.47929.8e

20. Kurtz TW, Griffin KA, Bidani AK, Davisson RL, Hall JE. Recommendations for Blood Pressure Measurement in Animals: Summary of an AHA Scientific Statement From the Council on High Blood Pressure Research, Professional and Public Education Subcommittee. *Arterioscler Thromb Vasc Biol*. 2005;25(3):478-479. doi:10.1161/01.ATV.0000153088.15433.8f

21. Grove M. *Mean Arterial Pressure in Acute Ischemic Stroke Study*. University of Tennessee Health Science Center; 2020. doi:10.21007/etd.cghs.2020.0511

22. Iii MR, Jr RWH, Medero R. Improved automated mean arterial blood pressure monitor with data enhancement. Published online January 14, 1987. Accessed March 9, 2023. https://patents.google.com/patent/EP0208521A2/en

23. Alpert BS, Quinn D, Gallick D. Oscillometric blood pressure: a review for clinicians. *J Am Soc Hypertens JASH*. 2014;8(12):930-938. doi:10.1016/j.jash.2014.08.014

24. Ramsey M. Noninvasive automatic determination of mean arterial pressure. *Med Biol Eng Comput*. 1979;17(1):11-18. doi:10.1007/BF02440948

25. Babbs CF. Oscillometric measurement of systolic and diastolic blood pressures validated in a physiologic mathematical model. *Biomed Eng OnLine*. 2012;11(1):56. doi:10.1186/1475-925X-11-56

26. Meidert AS, Saugel B. Techniques for Non-Invasive Monitoring of Arterial Blood Pressure. *Front Med*. 2018;4:231. doi:10.3389/fmed.2017.00231

27. Li Y, Wang B, Fan F, et al. Impact of atrial fibrillation on the accuracy of oscillometric blood pressure monitoring in ICU patients from a large real-world database. *J Hypertens*. 2023;41(5):838-844. doi:10.1097/HJH.0000000000003408

28. Stergiou GS, Alpert B, Mieke S, et al. A universal standard for the validation of blood pressure measuring devices: Association for the Advancement of Medical Instrumentation/European Society of Hypertension/International Organization for Standardization (AAMI/ESH/ISO) Collaboration Statement. *J Hypertens*. 2018;36(3):472-478. doi:10.1097/HJH.0000000000001634

29. Association for the Advancement of Medical instrumentation. Non-invasive sphygmomanometers- part 2: Clinical validation of automated measurement type ANSI/AAMI/ISO 81060-2:2019. Published online 2019.

30. Singer AJ, Kahn SR, Thode HC, Hollander JE. Comparison of forearm and upper arm blood pressures. *Prehosp Emerg Care*. 1999;3(2):123-126. doi:10.1080/10903129908958919

31. Naylor AJ, Sessler DI, Maheshwari K, et al. Arterial Catheters for Early Detection and Treatment of Hypotension During Major Noncardiac Surgery: A Randomized Trial. *Anesth Analg*. 2020;131(5):1540-1550. doi:10.1213/ANE.0000000000004370

32. Nguyen Y, Bora V. Arterial Pressure Monitoring. In: *StatPearls*. StatPearls Publishing; 2023. Accessed March 24, 2023. http://www.ncbi.nlm.nih.gov/books/NBK556127/

33. Lam S, Liu H, Jian Z, Settels J, Bohringer C. Intraoperative Invasive Blood Pressure Monitoring and the Potential Pitfalls of Invasively Measured Systolic Blood Pressure. *Cureus*. 13(8):e17610. doi:10.7759/cureus.17610

34. Weiner R, Ryan E, Yohannes-Tomicich J. Arterial Line Monitoring and Placement. In: Oropello JM, Pastores SM, Kvetan V, eds. *Critical Care*. McGraw-Hill Education; 1AD. Accessed March 24, 2023. accessanesthesiology.mhmedical.com/content.aspx?aid=1136419179

35. Lehman L wei H, Saeed M, Talmor D, Mark R, Malhotra A. Methods of Blood Pressure Measurement in the ICU. *Crit Care Med*. 2013;41(1):34-40. doi:10.1097/CCM.0b013e318265ea46

36. McEvoy MD, Gupta R, Koepke EJ, et al. Perioperative Quality Initiative consensus statement on postoperative blood pressure, risk and outcomes for elective surgery. *Br J Anaesth*. 2019;122(5):575-586. doi:10.1016/j.bja.2019.01.019

37. Meng L, Yu W, Wang T, Zhang L, Heerdt PM, Gelb AW. Blood Pressure Targets in Perioperative Care: Provisional Considerations Based on a Comprehensive Literature Review. *Hypertension*. 2018;72(4):806-817. doi:10.1161/HYPERTENSIONAHA.118.11688

38. Saugel B, Kouz K, Meidert AS, Schulte-Uentrop L, Romagnoli S. How to measure blood pressure using an arterial catheter: a systematic 5-step approach. *Crit Care*. 2020;24(1):172. doi:10.1186/s13054-020-02859-w

39. Romagnoli S, Ricci Z, Quattrone D, et al. Accuracy of invasive arterial pressure monitoring in cardiovascular patients: an observational study. *Crit Care*. 2014;18(6):644. doi:10.1186/s13054-014-0644-4

40. Pede S, Lombardo M. [Cardiovascular risk stratification. Systolic, diastolic or pulse pressure?]. *Ital Heart J Suppl Off J Ital Fed Cardiol*. 2001;2(4):356-358.

41. Bartels K, Esper SA, Thiele RH. Blood Pressure Monitoring for the Anesthesiologist: A Practical Review. *Anesth Analg*. 2016;122(6):1866-1879. doi:10.1213/ANE.0000000000001340

42. Irwin RS, Rippe JM, eds. *Irwin and Rippe's Intensive Care Medicine*. 8. edition. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2018.

43. Greenberg SM, Ziai WC, Cordonnier C, et al. 2022 Guideline for the Management of Patients With Spontaneous Intracerebral Hemorrhage: A Guideline From the American Heart Association/American Stroke Association. *Stroke*. Published online May 17, 2022:10.1161/STR.0000000000000407. doi:10.1161/STR.0000000000000407

44. Lim YH, Choi SY, Oh KW, et al. Comparison Between an Automated Device and a Manual Mercury Sphygmomanometer in an Epidemiological Survey of Hypertension Prevalence. *Am J Hypertens*. 2014;27(4):537-545. doi:10.1093/ajh/hpt100

45. Muecke S, Bersten A, Plummer J. The Mean Machine; Accurate Non-invasive Blood Pressure Measurement in the Critically Ill Patient. *J Clin Monit Comput*. 2009;23(5):283-297. doi:10.1007/s10877-009-9195-7

46. Rebesco MR, Pinkston MC, Smyrnios NA, Weisberg SN. A Comparison of Non-Invasive Blood Pressure Measurement Strategies with Intra-Arterial Measurement. *Prehospital Disaster Med*. 2020;35(5):516-523. doi:10.1017/S1049023X20000916

47. Grove MA, Paliwal M, Shearin A, et al. Manual and Oscillometric Blood Pressure in tPA-Treated Acute Ischemic Stroke: What Constitutes Agreement? *Stroke Vasc Interv Neurol*. 2023;3(4):e000711. doi:10.1161/SVIN.122.000711

48. Steiner LA, Andrews PJD. Monitoring the injured brain: ICP and CBF. *Br J Anaesth*. 2006;97(1):26-38. doi:10.1093/bja/ael110

49. Cerebral Perfusion Pressure - an overview | ScienceDirect Topics. Accessed March 7, 2023. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/cerebral-perfusion-pressure

50. Mount CA, M Das J. Cerebral Perfusion Pressure. In: *StatPearls*. StatPearls Publishing; 2022. Accessed January 24, 2023. http://www.ncbi.nlm.nih.gov/books/NBK537271/

51. Anderson CS, Huang Y, Arima H, et al. Effects of early intensive blood pressure-lowering treatment on the growth of hematoma and perihematomal edema in acute intracerebral hemorrhage: the Intensive Blood Pressure Reduction in Acute Cerebral Haemorrhage Trial (INTERACT). *Stroke 00392499*. 2010;41(2):307-312. doi:10.1161/STROKEAHA.109.561795

52. Wang X, Sandset EC, Moullaali TJ, et al. Determinants of the high admission blood pressure in mild-to-moderate acute intracerebral hemorrhage. *J Hypertens*. 2019;37(7):1463-1466. doi:10.1097/HJH.0000000000002056

53. Qureshi AI, Ezzeddine MA, Nasar A, et al. Prevalence of elevated blood pressure in 563704 adult patients with stroke presenting to the ED in the United States. *Am J Emerg Med*. 2007;25(1):32-38. doi:10.1016/j.ajem.2006.07.008

54. Kazui S, Minematsu K, Yamamoto H, Sawada T, Yamaguchi T. Predisposing Factors to Enlargement of Spontaneous Intracerebral Hematoma. *Stroke*. 1997;28(12):2370-2375. doi:10.1161/01.STR.28.12.2370

55. Davis SM, Broderick J, Hennerici M, et al. Hematoma growth is a determinant of mortality and poor outcome after intracerebral hemorrhage. *Neurology*. 2006;66(8):1175-1181. doi:10.1212/01.wnl.0000208408.98482.99

56. Hemphill JC, Farrant M, Neill TA. Prospective validation of the ICH Score for 12-month functional outcome. *Neurology*. 2009;73(14):1088-1094. doi:10.1212/WNL.0b013e3181b8b332

57. Dusenbury W, Tsivgoulis G, Chang J, et al. Validation of the National Institutes of Health Stroke Scale in Intracerebral Hemorrhage. *Stroke Vasc Interv Neurol*. 2023;3(4):e000834. doi:10.1161/SVIN.123.000834

58. Jauch EC, Saver JL, Adams HP, et al. Guidelines for the Early Management of Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*. 2013;44(3):870-947. doi:10.1161/STR.0b013e318284056a

59. Powers WJ, Rabinstein AA, Ackerson T, et al. 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*. 2019;50(12):e344-e418. doi:10.1161/STR.0000000000000211

60. Hoh BL, Ko NU, Amin-Hanjani S, et al. 2023 Guideline for the Management of Patients With Aneurysmal Subarachnoid Hemorrhage: A Guideline From the American Heart Association/American Stroke Association. *Stroke*. 2023;54(7):e314-e370. doi:10.1161/STR.0000000000000436

61. Gobiet W, Grote W, Bock WJ. The relation between intracrainal pressure, mean arterial pressure and cerebral blood flow in patients with severe head injury. *Acta Neurochir (Wien)*. 1975;32(1-2):13-24. doi:10.1007/BF01405899

62. Jovin TG, Demchuk AM, Gupta R. PATHOPHYSIOLOGY OF ACUTE ISCHEMIC STROKE: *Contin Lifelong Learn Neurol*. 2008;14:28-45. doi:10.1212/01.CON.0000275639.07451.e7

63. Lam AM. Emergency Neurological Life Support: Intracerebral Hemorrhage. :15.

64. Magid-Bernstein J, Girard R, Polster S, et al. Cerebral Hemorrhage: Pathophysiology, Treatment, and Future Directions. *Circ Res*. 2022;130(8):1204-1229. doi:10.1161/CIRCRESAHA.121.319949

BRAVEST: A Visual Teaching Aid for Stroke Clinicians

Linda Sugrue, MSN, RN, SCRN, ASC-BC

Abstract

Stroke clinicians incorporate essential stroke care measures into their professional practice within certified stroke centers on a regular basis. Supported by evidence-based guidelines, these time-sensitive care requirements target the unique needs of stroke patients making them essential for optimal translation to bedside clinical practice. Varied interprofessional staff learning styles call for educational instruction to be engaging and innovative to yield intended results. This article introduces a new learning tool called *BRAVEST* (B: Blood pressure; R: Rehabilitation; A: Antithrombotics; V: Venous thromboembolism prophylaxis; E: Education; S: Statin therapy; T: Thrombolysis/Thrombectomy), a custom-made visual aid that presents evidence-based, certification-required acute stroke care as a creative mnemonic infographic to enhance interprofessional stroke clinicians' learning and retention.

Key words: Acute stroke, clinical education, knowledge retention, education modalities, teaching-learning methods.

INTRODUCTION

Interprofessional stroke clinicians that practice in certified stroke centers must be confident in their delivery of neurovascular care.[1] Clinical proficiency in acute stroke processes and secondary stroke prevention performance measures requires specialized knowledge that is best reinforced with stroke-specific education. Such training is especially important in centers where clinicians practice on mixed medical-surgical units instead of highly specialized stroke units. In the United States, regulatory bodies including The Joint Commission[2] and Det Norske Veritas[3] require annual stroke education for staff working within all levels of stroke certified hospitals, with programs often assigning routine, adynamic learning modules to ensure attainment of required educational hours. However, this form of didactic education can be unengaging and non-specific, lacking the focus necessary to drive performance improvement and retention of meaningful practice information. This results in a gap between authentic knowledge attainment and practical application of new material that is evident at the bedside, and ultimately may impact patient wellbeing through care delivery errors, and loss of hospital specialty certification. Zelenikova and colleagues found that for nurses, potential errors degrade self-confidence, and lead to work dissatisfaction[4] and although these investigators' work was limited to nurse subjects, it is likely applicable to all stroke clinicians. To ensure educational efforts prepare clinicians for the practice environment, targeted content on stroke performance measures should be included in stroke training activities. The aim of this project was to develop an engaging mnemonic infographic to meet this need as an innovative visual teaching tool to complement didactic education.

LITERATURE REVIEW

Learning occurs differently in each person, requiring instructional strategies that consider two key elements: 1) The educational content being shared; and 2) the teaching modality being utilized. A literature search was conducted to examine evidence supporting mnemonic infographics as effective teaching and learning tools to enhance knowledge retention and practice change in healthcare. Search terms included *education*, *infographics*, *mnemonics*, *multimedia learning*, and *visual learning tools*. Three major recurring themes emerged from this review: 1) Visual learning; 2) cognitive processing; and 3) knowledge transfer.

Visual Learning

Visual learning modalities are one of the most important methods that educators utilize to meet the needs of learners.[5] Polowsky and Steciuch[6] demonstrated that instruction with multi-media infographic tools utilizing visual graphics and animation yielded more knowledge in food science students than traditional lessons that lacked visual aids. Infographics used in a hybrid learning environment have also been shown to have a positive effect on physics students' attitudes toward technology in learning.[7] Visual infographics have also been found to be beneficial and convenient as a method to summarize full length text articles.[8]

Cognitive Processing

Learning is impacted by the content of instructional materials as well as the learner's cognitive processing.[9] Learning materials featuring the same information presented by more than one source and method (*content redundancy*) as in multimedia content, leads to better learning outcomes than when presented concurrently using a singular source.[9] In another study on infographic use in second language learning among Arabic speaking students, Alwadei and Ali Mohsen[10] found that the experimental student group who received instruction via visual means achieved better scores on vocabulary recognition and vocabulary production than control group students who received traditional teaching. These results were no surprise given that infographic learning aligns with Robert Mayer's Cognitive Theory of Multimedia Learning which postulates that learners process information better when pictures and words are presented in combination.[11] Additionally, Ongor and Uslusoy[5] explored use of multimedia-based education in a cohort of nursing students, finding that those in the experimental group who received multiple visual applications in their instruction achieved better cognitive learning outcomes then those in the control group who received only simple power point instruction.

Knowledge Transfer

Knowledge transfer initiated by an educator using visual educational tools can lead to behavior change. Egan and colleagues found that the use of infographics decreased cognitive burden and increased knowledge attainment, compared to teaching that lacked visual stimulation.[12] Mnemonic checklists utilized by hospital clinical teams have also been shown to trigger learning and behavior alignment in care delivery that leads to improved patient safety.[13] Page and colleagues found that use of visual mnemonic learning tools by nurses resulted in increased recall, knowledge, and improved rates of education of cancer patients.[14] Similar results were found by Carter and colleagues who found that use of a mnemonic was associated with improved workflow compliance in the identification of penicillin allergies.[15]

Collectively, the evidence that supports infographic mnemonic learning demonstrates the effectiveness of this method to improve visual learning, cognitive processing, and knowledge transfer. These findings support the development of a learning tool focused on required acute stroke knowledge using this innovative approach.

DEVELOPMENT OF *BRAVEST*

BRAVEST was designed using a framework the encompassed visual learning, cognitive processing, and knowledge transfer principles, making it a non-traditional teaching tool to complement standard didactic instruction for stroke clinicians. BRAVEST is an original design that features mnemonic infographic content that converts leading evidence-based stroke care into a single visual aid to guide and impart knowledge on stroke performance measures and improve translation to practice (Figure 1). In alignment with Robert Mayer's Cognitive Theory of Multimedia Learning,[11] BRAVEST is an example of instructional material that stimulates visual cognitive pathways to promote learning by presenting text and images together.

BRAVEST was designed using the web-based Canva® graphic design application.[16] The mnemonic is depicted vertically and spells out BRAVEST using the first letter of each key word on the graphic. Next to each line of text is a Canva®-generated graphic image that corresponds to each key word. Each letter of BRAVEST is a specific stroke care item assimilated from the American Heart Association / American Stroke Association clinical practice guidelines for acute ischemic stroke:[17]

B: Blood pressure (know parameters); image of blood pressure cuff.
R: Rehabilitation (PT, Speech & Swallow); image of a woman speaking and physical therapist walking a patient.
A: Antithrombotics (both antiplatelets and anticoagulants); image of a bottle of aspirin.
V: Venous thromboembolism prophylaxis (mechanical or anticoagulant); image of a lower leg with arrows pointing inward.
E: Education (patient and family); image of an open book with a hovering brain.
S: Statin therapy (high intensity); image of a cross section of a cholesterol-lined artery.
T: Thrombolysis (and thrombectomy); image of pink brain with darkened area of stroke.

The infographic's multimedia elements were chosen to enable learners to visualize information.[18] The configuration of text and picture together aim to generate the cognitive eye and mind connection.[19] The checklist-like layout of mnemonic and text intends to assist learners with mental organization.[20] The back of the BRAVEST graphic displays a reference list in a visually similar layout citing available resources demonstrating to users the necessary connection between the educational content and evidence-based practice recommendations. As an added creative element, the term BRAVEST carries a known definition that relates conceptually to moral strength and courage.[21] As such, the mnemonic and title BRAVEST are expected to carry a positive association to motivate stroke clinicians to apply evidence in practice supported by use of the learning tool.

Introducing BRAVEST to stroke clinicians should occur in tandem with the descriptions of each corresponding care item listed in Table 1. Comprehension of the rationale behind stroke treatment and how it applies to practice are central to ensuring that evidence-based care is rendered appropriately to acute

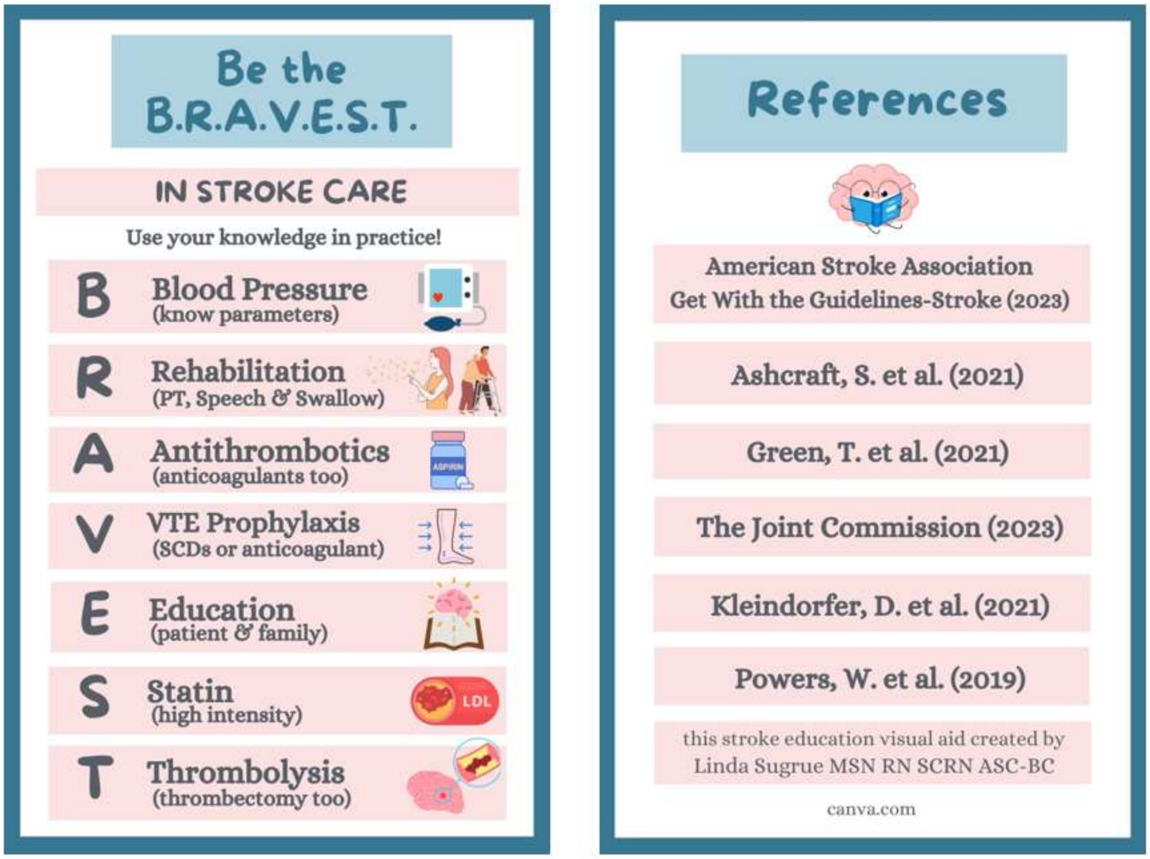


Figure 1: The BRAVEST Mnemonic Infographic

stroke patients. Shifting from tasks to performance measures has the potential to leverage and elevate clinical practice while promoting clinician empowerment as competent and trusted providers. A critical factor in provision of effective education is creation of a learning environment where clinicians can become self-sufficient in the delivery of safe and effective care.[22] BRAVEST takes a big step toward stimulating self-sufficiency, supporting development of such a learning environment.

An original slide deck with custom voice over was designed to partner with BRAVEST to detail each element of the mnemonic. Stroke clinical leaders are encouraged to use BRAVEST to complement standard formal stroke-specific education that is provided to interprofessional staff. In the clinical environment, BRAVEST can also be used as a change of shift guide to enhance targeted communication of care delivery during patient handoffs. Other creative uses of the tool should be encouraged and shared via stroke-specific listservs such as the Association of Neurovascular Clinicians (ANVC) Member Discussion Forum.[23] Unit educators or managers should consider using BRAVEST to engage staff in the presentation of elements of the mnemonic to the team at weekly huddles. The graphic can also be modeled into badge tags and distributed to all interprofessional staff as a clinical reference. BRAVEST can be enlarged into a laminated poster for stroke unit bulletin boards or digitalized for posting to the stroke page of a certified stroke center's internal intranet.

Table 1: BRAVEST Education Key Points

Stroke Care Item	Description	Key Stroke Clinician Knowledge Points
B: Blood Pressure	• Careful balance to maintain safe and adequate brain perfusion • Permissive hypertension ranges and time windows	• Know frequency, parameters, range, processes for intervention • Report clearly during handoffs • Document responsibly and timely in medical record
R: Rehabilitation	• Physical therapy (PT) & speech/language pathology (SLP) evaluations • Disability and ambulation assessment • Strategies tailored to individual needs: Maximize mobility, determine diet consistency/modification, maintain patient safety • Occurs prior to discharge	• Dysphagia screening prior to any oral intake • Align care with PT/SLP recommendations i.e. ambulation aids, positioning, feeding, etc. • Communicate in handoff, with emphasis on swallow status and mobility status • Document responsibly and timely in medical record
A: Antithrombotics for Secondary Stroke Prevention	• Time-sensitive secondary stroke prevention medications • Antiplatelets or anticoagulants • Administered on day of arrival or day after arrival • Prescribed at discharge	• Nil per os (NPO) not disqualifier for aspirin; give via suppository as directed • Telemetry or hard-wired cardiac monitoring to capture atrial fibrillation or flutter; consider loop recorder implantation • Communicate with providers • Include information in handoffs • Document responsibly and timely in medical record

V: Venous Thromboembolism (VTE) Prophylaxis	• Immobility places patients at risk for VTE
	• Time-sensitive, administered on day of arrival or day after arrival
	• Modalities:
	  ○ Mechanical (intermittent [sequential] pneumatic compression devices or Geko T3 neuromuscular stimulator strips);
	  ○ Chemical (subcutaneous or oral anticoagulants)
		• Antiplatelets or dual antiplatelets alone do not provide VTE prophylaxis
		• Include information in handoffs
		• Document responsibly and timely in medical record

E: Education	• Secondary stroke prevention measures; key information to include:
	  ○ Activation of ambulance
	  ○ Post-discharge follow-up
	  ○ Prescribed discharge medications
	  ○ Stroke warning signs and symptoms
	  ○ Stroke risk factors including individual risk factors
		• A key scope of practice item
		• Provide language appropriate materials and obtain feedback
		• Engage families if patient is unable to participate in education
		• Utilize TEACH BACK method and visual aids
		• Report clearly in handoffs
		• Document responsibly and timely

S: Statin Therapy for Secondary Stroke Prevention	• Time-sensitive measure • High-intensity dose per LDL, age, tolerance • Prescribed at discharge	• Know LDL goals • Report intolerance • Communicate in handoffs • Document clearly

T: Thrombolysis & Thrombectomy	• Time-sensitive rescue treatments for acute ischemic stroke • Triggered by early recognition of signs and symptoms • How to activate a stroke alert • Eligibility criteria to establish candidacy	• Know and utilize BEFAST • Identify and report deviations from patient's baseline • Have clear understanding of stroke alert processes and treatment windows • Assist with fact-finding, last known well, medications, stroke scale scoring • Perform handoffs including side by side neuro assessment • Perform serial neuro assessments and vital signs • Collaborate and communicate with other disciplines • Document responsibly and timely
References	• List of Clinical Practice Guidelines (CPG) • Evidence-based literature supporting care items listed on BRAVEST	• Know which CPGs guide the hospital's stroke program • Know how to access CPGs in your facility

CONCLUSION

Bedside stroke clinicians benefit from education that corresponds to their practice specialization. The non-traditional, creative, innovative instructional material represented by BRAVEST was developed in response to targeted stroke clinician learning needs related to performance measures. Supported by literature, the BRAVEST mnemonic infographic provides a multimedia approach to education, with multiple visual elements designed to communicate information to learners in an engaging way that promotes cognitive learning. BRAVEST content adds to the specialization efforts of stroke clinicians charged with maintaining high standards of practice and meeting hospital regulatory expectations.

Author Affiliations

Linda Sugrue, MSN, RN, SCRN, ASC-BC
Clinical Program Manager, Stroke Center
Northwell Health – Phelps Hospital
701 North Broadway
Sleepy Hollow, NY 10591 USA
lsugruemsn@gmail.com

REFERENCES

1. Green TL, McNair ND, Hinkle JL, Middleton S, Miller ET, Perrin S, Power M, Southerland AM, Summers DV. (2021). Care of the patient with acute ischemic stroke (post hyperacute and prehospital discharge): Update to 2009 comprehensive nursing care scientific statement: A scientific statement from the American Heart Association. *Stroke*. 2021;52(5). https://doi.org/10.1161/str.0000000000000357
2. The Joint Commission. Stroke certification. https://www.jointcommission.org. Accessed April 25, 2024.

3. Det Norske Veritas (DNV). Stroke care certification program. DNV Healthcare Stroke Care Certification Program. Accessed April 25, 2024.
4. Zelenikova R, Jarosova D, Plevova I, Janikova E. Nurses' perceptions of professional practice environment and its relation to missed nursing care and nurse satisfaction. *International Journal of Environmental Research and Public Health*. 2020;17(11):3805. https://doi.org/10.3390/ijerph17113805
5. Ongor M, Uslusoy EC. The effect of multimedia-based education in e-learning on nursing students' academic success and motivation: A randomised controlled study. *Nurse Education in Practice.* 2023;71:103686–103686. https://doi.org/10.1016/j.nepr.2023.103686.
6. Polowsky P, Steciuch CC. Interactive info-graphics improve learning outcomes in a food science laboratory exercise Environment. *Journal of Career and Technical Education.* 2020;35(1):1. https://doi.org/10.21061/jcte.v35i1.a1.
7. Kumaş A. Infographics and their applications in the hybrid learning process. *Acta Didactica Napocensia*. 2022;15(2):230–242. https://doi.org/10.24193/adn.15.2.15.
8. Zadro J, Ferreira GE, O'Keeffe M, Stahl-Timmins W, Elkins MR, Maher CG. How do people use and view infographics that summarise health and medical research? A cross-sectional survey. *BMC Medical Education.* 2022; *22*(1):1–677. https://doi.org/10.1186/s12909-022-03744-6.
9. Albers, F, Trypke M, Stebner F, Wirth J, Plass JL. Different types of redundancy and their effect on learning and cognitive load. *British Journal of Educational Psychology*. 2023;*93*(S2): 339–352. C
10. Alwadei A, Mohsen MA. Investigation of the use of infographics to aid second language vocabulary learning. *Humanities & Social Sciences Communications*, 2023;10(1):108–111. https://doi.org/10.1057/s41599-023-01569-2.
11. Theimer S. Expanding libraries' application of Mayer's cognitive theory of multimedia learning. *Library Management*. 2019;40(6/7):478–482. https://doi.org/10.1108/LM-08-2018-0067.
12. Egan M, Acharya A, Sounderajah V, Xu Y, Mottershaw A, Phillips R, Ashrafian H, Darzi A. Evaluating the effect of infographics on public recall, sentiment and willingness to use face masks during the COVID-19 pandemic: a randomised internet-based questionnaire study. *BMC Public Health*. 2021;21(1), 367–367. https://doi.org/10.1186/s12889-021-10356-0.
13. Radhakrishnan Lukose K, Cartwright R, Sleiman A, Matey N, Lim D, LeGault T, Pollard S, Gravina N, Southwick FS. Prospective application of the interdisciplinary bedside rounding checklist "TEMP" is associated with reduced infections and length of hospital stay. *BMJ Open Quality*. 2022;11(4), e002045. https://doi.org/10.1136/bmjoq-2022-002045.
14. Page C, Cordon C, Wong J. Evaluating the effectiveness of a mnemonic to guide staff when providing patient education to autologous hematopoietic stem cell transplant patients. *Canadian Oncology Nursing Journal*. 2019;29(2), 123–131. https://doi.org/10.5737/23688076292123131.
15. Carter E, Schramm C, Baron K, Zolla M, Zavez K, Banach D. Perceived usefulness of a mnemonic to improve nurses' evaluation of reported penicillin allergies. *Antimicrobial Stewardship & Healthcare Epidemiology: ASHE.* 2023; 3(1):e124–e124. https://doi.org/10.1017/ash.2023.177.

16. Canva. Canva Design Suite. https://www.canva.com/. Accessed April 25, 2024.
17. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, Jauch EC, Kidwell CS, Leslie-Mazwi TM, Ovbiagele B, Scott PA, Sheth KN, Southerland AM, Summers DV, Tirschwell DL. 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. 2019 Dec;50(12):e344-e418. doi: 10.1161/STR.0000000000000211. Epub 2019 Oct 30. Erratum in: Stroke. 2019 Dec;50(12):e440-e441. PMID: 31662037.
18. Chicca J, Chunta K. Engaging Students with Visual Stories: Using infographics in nursing education. *Teaching and Learning in Nursing.* 2020;15(1):32–36. https://doi.org/10.1016/j.teln.2019.09.003.
19. Güney Z. Visual literacy and visualization in instructional design and technology for learning environments. *European Journal of Contemporary Education*, 2019;8(1):103-117
20. Chapman V, Cantey D. HI I CARE: A mnemonic device to frame safe patient encounters and support simulation experiences for novice nursing students. *Teaching and Learning in Nursing.* 2020;15(4), 215–217. https://doi.org/10.1016/j.teln.2020.05.001
21. Merriam-Webster. (n.d.). Brave. In Merriam-Webster.com dictionary. Retrieved March 5, 2024, from https://www.merriam-webster.com/dictionary/brave.
22. Rao B. Innovative teaching pedagogy in nursing education. *International Journal of Nursing Education*. 2019;11(4), 176–. https://doi.org/10.5958/0974-9357.2019.00114.4
23. Association of Neurovascular Clinicians. ANVC Discussion Forum. www.anvc.org. Accessed April 25, 2024.

AcT: Intravenous Tenecteplase Compared to Alteplase for Acute Ischaemic Stroke in Canada

The Alteplase compared to Tenecteplase (AcT) study was a multicenter randomized controlled trial[1] conducted in 22 primary and comprehensive stroke center hospitals across Canada. Findings from AcT are likely currently under review by the United States Food & Drug Administration (US-FDA), although presently it remains unknown whether study findings will change the American drug regulatory label for Tenecteplase (TNK). In this article, we detail the trial's design and important clinical findings.

The AcT study enrolled ischemic stroke patients that were at least 18 years in age and presented with disabling deficits within 4.5 hours of symptom onset. Patients had to meet current Canadian guideline criteria for thrombolysis; additionally, patients eligible for mechanical thrombectomy were eligible for enrollment in the study.[1] Once enrolled, patients were randomly assigned 1:1 by computer algorithm to receive either alteplase (0.9 mg/kg to a maximum of 90 mg [10% bolus; remaining 90% delivered over 60 minutes]) or TNK (0.25 mg/kg to a maximum of 25 mg).

The primary endpoint of the clinical trial was the proportion of patients that achieved a modified Rankin Scale (mRS) score of 0 or1 at between 90 to 120 days after treatment.[1] Secondary endpoints examined mRS 0-2, differences on the EuroQol visual analog scale (EQ-VAS), return to baseline function, extended Thrombolysis in Cerebral Infarction (eTICI) recanalization score in patients receiving thrombectomy, door to needle time, and numerous other outcomes; because the focus of this article is on the primary outcome (mRS 0-1), results of these additional secondary endpoint analyses are not detailed in this review. An intention-to-treat approach was utilized for the presentation of the definitive results, whereby all patients randomized that did not withdraw consent, were analyzed and reported even if they subsequently never received thrombolysis.

The AcT study was designed to determine whether TNK was non-inferior to alteplase. Non-inferiority trials aim to determine if a new treatment is capable of achieving similar outcomes to a gold standard treatment. These types of clinical trials set a non-inferiority margin; if results are better than this set threshold, the new treatment is deemed "non-inferior" to the gold standard. There is no set standard for what constitutes an acceptable non-inferiority margin, and because of this, margins vary substantially between trials. The larger the margin, the easier it is for the new treatment to be found non-inferior to the gold standard, whereas the smaller the margin, the more rigorous the non-inferiority standard. In considering acceptance of non-inferiority clinical trial results, reviewers should think about whether findings meet clinical acceptability. For example, a 20% inferiority margin would mean that the new treatment would be considered acceptable, even though 20% of subjects did not achieve the targeted outcome. In AcT, investigators set a 5% non-inferiority margin, meaning that

TNK would be considered non-inferior if the difference in mRS 0-1 endpoint attainment exceeded 5%.[1]

Investigators also assessed safety differences between the TNK and alteplase groups. Symptomatic intracerebral hemorrhage (sICH) occurring within 24 hours of treatment was measured; sICH was defined in the trial as any intracerebral hemorrhage temporally related to treatment and directly responsible for worsening of neurologic status, that in the opinion of the local investigator was the most important factor causing neurological worsening. All cause death occurring after treatment was also measured.[1]

All study hospitals were participants in stroke quality registries, namely the Quality Improvement and Clinical Research (QuiCR) registry, or the Optimizing Patient Treatment in Major Ischemic Stroke with EVT (OPTIMISE) registry. Data entry into these registries was overseen to ensure completeness, and both baseline patient characteristics and workflow process data were integrated into the trial database.[1]

The trial was open-label, meaning that clinicians managing enrolled patients knew which drug was given to each of their subjects. Because of this knowledge, the mRS study endpoint was measured over telephone by an assessor blinded to treatment group at between 90 and 120 days from the date of enrollment.

AcT enrolled a total of 1600 patients between December 2019 and January 2022. Of these, 23 patients withdrew consent from the study so that 1577 patients were ultimately analyzed with 806 (51%) that received TNK and 771 (49%) that received alteplase. Baseline characteristics and workflow processes were similar between groups, with the overall median age 74 (IQR 63-83) years, and 52.1% were male. Investigators reported that only 10 (0.6%) patients were lost to follow-up, reflecting excellent study quality.

Median time to measurement of the mRS 0-1 primary endpoint was 97 (IQR 91-111) days and did not differ between groups. A total of 296 out of 802 (36.9%) patients in the TNK group achieved an mRS 0-1, compared to 266 out of 765 (34.8%) patients in the alteplase group; the unadjusted risk difference was 2.1% (95% CI: -2.6 to 6.9). Since the lower bound 95% CI was -2.6% and greater than the threshold -5%, TNK was found to be non-inferior to alteplase. Further analyses showed that while TNK was non-inferior to alteplase, it was not found to be significantly superior to alteplase. Overall, there were no significant differences in sICH or any type of intracranial hemorrhage. Death within 90-days was also similar between the TNK and alteplase groups, and other adverse events (peripheral bleeding and orolingual angioedema) were rare in both groups.

While it remains unknown whether the US-FDA will change the regulatory label for TNK to include acute ischemic stroke treatment up to 4.5 hours from symptom onset, many other countries have already taken this step. Use of TNK offers the significant advantage of single bolus treatment due to its longer half-life, and some have suggested that there may be a cost advantage in hospitals that lack large buyer purchase agreements. Regardless of US-FDA regulatory approval, TNK is likely here to stay in the treatment of acute ischemic stroke, and the findings of this important clinical trial should help to reduce any remaining angst related to TNK adoption.

References

1. Menon BK, Buck BH, Singh N, et al.; AcT Trial Investigators. Intravenous tenecteplase compared with alteplase for acute ischaemic stroke in Canada (AcT): a pragmatic, multicentre, open-label, registry-linked, randomised, controlled, non-inferiority trial. Lancet. 2022 Jul 16;400(10347):161-169. doi: 10.1016/S0140-6736(22)01054-6. Epub 2022 Jun 29. PMID: 35779553.

A Drive Interrupted: Stroke of the Anterior Choroidal Artery – A Case Report

Alex H. Brown,[1] BS, Thomas C. Varkey, MD, MBA, MEd,[1,2] Savdeep Singh, MD[1]

Abstract

The anterior choroidal artery (AChA) is the most distal branch of the internal carotid artery (ICA) The ACHA is significant because it supplies important structures in the brain, including the optic tract, anterior portion of cerebral peduncle, lateral geniculate body, uncus, globus pallidus, posterior and superficial areas of the thalamus, and the retrolenticular and posterior portions of the internal capsule on the same side as the artery. Isolated strokes involving the AChA are rare and can result in HHH Syndrome, consisting of contralateral hemiplegia, hemisensory loss, and homonymous hemianopia. Features which distinguish an AChA infarction from larger arterial pathology are lack of headache and lack of depressed level of consciousness in subacute infarction, and usually lack of aphasia acutely. The etiology remains controversial, with proposed mechanisms including cardioembolic, large-vessel atherosclerosis, dissection of the ICA, small-vessel occlusion, and cryptogenic causes. Herein, the authors report a case of an isolated AChA infarction resulting in a right-sided, pure motor hemiparesis with no sensory or vision loss, highly suggestive of cardioembolic origin, with the evaluation of the patient, and eventual treatment strategy.

Key words: Anterior Choroidal Artery, Rare Stroke Pathologies, Case Report, Cardioembolic, Small Vessel Disease, HHH Syndrome.

INTRODUCTION

The anterior choroidal artery (AChA) is the most distal branch of the internal carotid artery (ICA) after it enters the skull base. It arises most commonly after the posterior communicating artery.[1] The AChA is significant because it supplies important structures in the brain, including the optic tract, anterior portion of cerebral peduncle, lateral geniculate body, uncus, globus pallidus, posterior and superficial areas of the thalamus, and the retrolenticular and posterior portions of the internal capsule on the same side as the artery.[1] Isolated strokes involving the AChA are rare and can result in AChA syndrome, which classically presents as a triad of contralateral hemiplegia, hemisensory loss, and homonymous hemianopia commonly referred to as HHH Syndrome.[2] Incomplete forms of the AChA syndrome are common, with motor deficits being the most frequently seen clinical symptom followed by hemisensory loss.[3,4] Features that can distinguish an AChA infarction from a larger arterial pathology are lack of depressed level of consciousness and lack of headache with infarct evolution, and typically absence of aphasia in patients with right-sided motor and sensory deficits.[5] The etiology of AChA infarcts remains controversial, with proposed mechanisms that include cardioembolism, large-vessel atherosclerosis, dissection of the ICA, small-vessel occlusion, and cryptogenic causes.[4,6] We report a case of an isolated AChA infarction resulting in a right-sided, pure motor hemiparesis with no sensory or vision loss, highly suggestive of cardioembolic origin.

THE CASE

A 56-year-old, right-handed man with a history of untreated hypertension presented to the emergency department (ED) with right-sided face, arm, and leg weakness. He had been driving an hour before arrival and noted that he was becoming weak. He finished his drive home and called for the paramedics who appropriately brought him to a comprehensive stroke center. His National Institutes of Health Stroke Scale (NIHSS) score was 7 (item 4 = 2 points [right lower facial weakness]; item 5 = 2 points [right arm motor weakness]; item 6 = 2 points [right leg motor weakness]; item 10 = 1 point [dysarthria]). He was afebrile with stable vital signs. Neurologically, he was alert and oriented, with a Glasgow Coma Scale score of 15. He had no apparent visual field deficit or sensory disturbance. He denied any prior seizure, stroke, recent trauma, infection, and tobacco use. Initial computed tomography (CT) scan of the head without contrast was negative for subacute infarction or hemorrhage, CT angiography was negative for large vessel occlusion, and CT perfusion was negative for any perfusion deficit. Following a discussion of the risks and benefits, the decision was made with the patient and family to treat with tenecteplase (TNK) which was administered without complications.

The following day, fluid attenuated inversion recovery magnetic resonance imaging of the head showed a left anterior choroidal stroke which affected the insula and some structures of the basal ganglia, including the posterior lentiform nucleus extending to the caudate body (Figure 1). Mild chronic small vessel ischemic disease was also noted. Because of the vessel affected, the team discussed potential causes of the large vessel disease, and the patient underwent cardiac workup to determine the etiology of the stroke. Transesophageal echocardiogram (TEE) revealed a small atrial septal aneurysm (ASA) and a small patent foramen ovale (PFO) with late appearing bubbles and no evidence of intracardiac masses or thrombi. Discussion with the cardiology team revealed that based on the small size of the shunt, they did not believe that it was large enough to warrant closing. Discussion was had with our outpatient ultrasound technologist to reevaluate the small shunt using transcranial Doppler in the outpatient clinic. Cardiac monitoring during his inpatient stay did not reveal evidence of paroxysmal atrial fibrillation (AF). An implantable loop recorder was placed to monitor for possible paroxysmal AF.

During the patient's stay, evaluation for secondary causes of stroke were identified and treated. His urine drug screen was

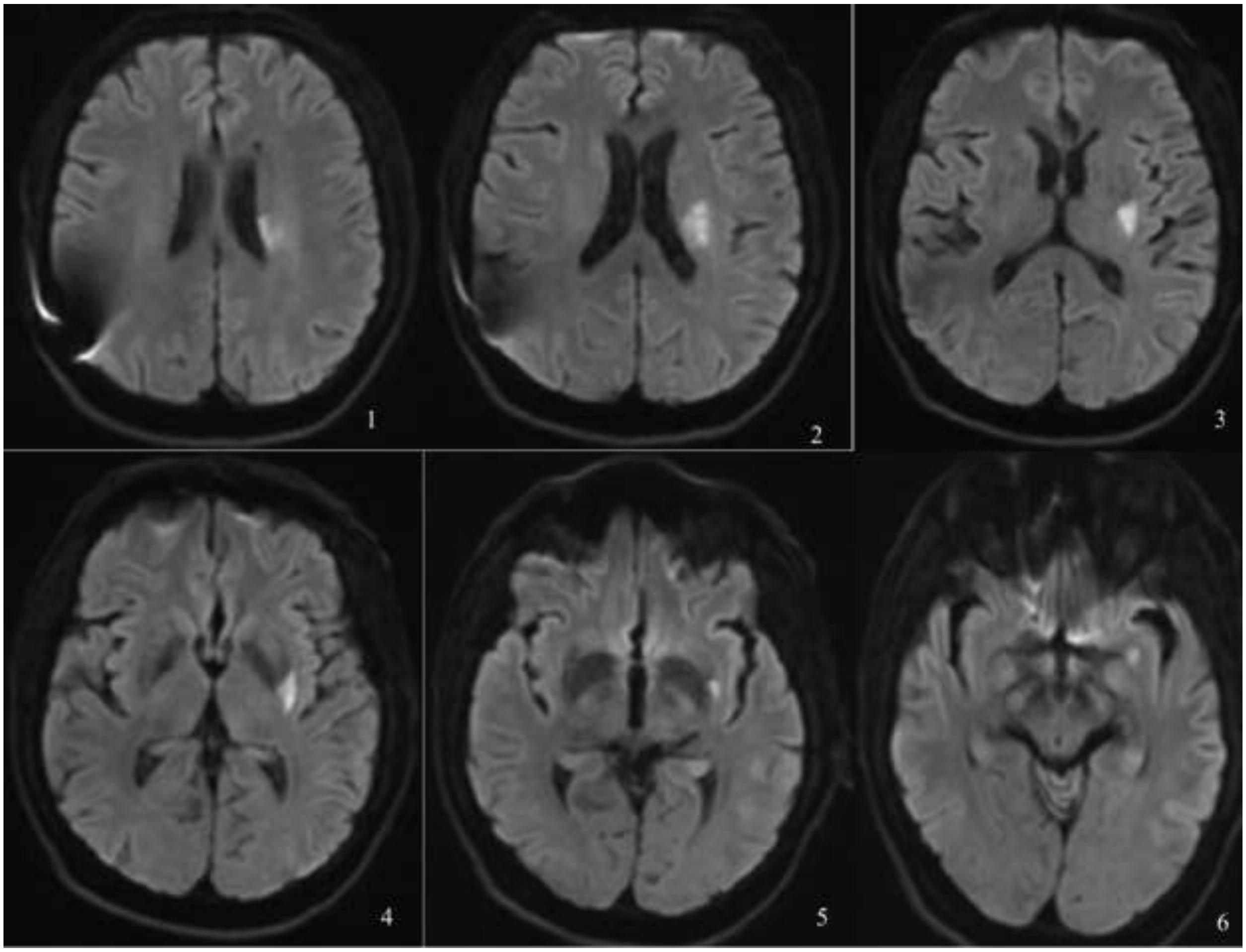


Figure 1: T2 FLAIR images presented from superior (slice 1) to inferior (slice 6) with signal located in the classically described tract of the anterior choroidal artery; note some patchy sparing of the most distal portions of the arterial tract likely from the administration of Tenecteplase.

negative for any illicit substances. The patient initially presented with a hypertensive emergency requiring nicardipine and intensive care unit admission, and required continued treatment for hypertension throughout his hospital stay with losartan 100 mg, carvedilol 6.25 mg, and hydrochlorothiazide 25 mg. His hemoglobin-A1c was 5.6% and low-density lipoprotein was 140 mg/dL. He was placed on atorvastatin 40 mg and aspirin 81 mg daily for secondary stroke prevention. The patient was discharged after 4 days with no further complications, except continued right-sided face, arm, and leg weakness exhibiting no change or improvement. He was referred for occupational and physical therapy.

DISCUSSION

The origin of isolated AChA infarcts has been a subject of debate in the literature for many years. The area supplied by the AChA is frequently involved in larger infarcts of the internal carotid artery, further complicating research on the topic. Earlier studies suggested that isolated AChA infarcts were most commonly caused by lipohyalinosis of the small and deep branches of the AChA, or small vessel disease (SVD).[6] More recent research has indicated that this is not always true, with many cases of AChA strokes involving cardioembolic and large vessel atherosclerosis etiology.[4] This suggests that cardiac workup may be needed to determine the cause of the stroke in order to manage and treat patients appropriately.

The patient arrived to the ED with pure motor hemiparesis, which are most classically associated with lacunar infarcts of the internal capsule, corona radiata, or the corticospinal tracts in the brain stem (most commonly in the pons). Lacunar infarcts generally develop in patients with hypertension, diabetes, hyperlipidemia, or a mixture of all three.[7,8] Our patient's history of hypertension fit the clinical description for a classic lacunar infarct, suggesting that a cardioembolic source was unlikely. Upon further imaging, it was noted that the patient's infarct was in the anterior choroidal artery territory, a vessel which at one time was generally thought to be damaged secondarily to SVD. However, based on the newest findings in the literature, it was appropriate to continue evaluation for cardiac causes of the stroke.[4] At hospital discharge, both imaging and advanced work up failed to provide a clear cause of the patient's stroke. Nevertheless, the patient received a cardiac work up with associated TEE study, revealing an ASA and small PFO. Both ASA and PFO have been associated with a higher risk of cardiac arrhythmias, including AF, and cryptogenic stroke;[9-11] although not observed during cardiac monitoring at the hospital, it is possible the patient has paroxysmal AF aggravated by the ASA and PFO. The patient will receive transcranial Doppler bubble testing outpatient to further assess the functionality of the right-to-left shunt.

CONCLUSIONS

This case report highlights the importance of investigating the etiology of isolated AChA strokes, as they may not all be caused by SVD. Cardiac workup may in some cases reveal a cardioembolic source, which would drastically change the management and treatment of these patients. In the evaluation of patients with rare pathologies, it is appropriate to widen the differential and perform further testing to prevent future strokes. This is especially important in young patients, recognizing that in such cases rare etiologies may not in and of themselves be rare, but instead undiagnosed.[12] It is the hope of these authors that this case helps to improve clinical gestalt in the determination of pathogenic mechanism for these patients.

Author Affiliations

Alex Brown, BS
University of Arizona, Phoenix, College of Medicine[1]
alexhbrown@arizona.edu

Thomas Varkey, MD
University of Arizona, Phoenix, College of Medicine, Department of Neurology[1]
Grand Canyon University, The Colangelo College of Business, Phoenix, Arizona[2]

tvarkey@utexas.edu

Savdeep Singh, MD
University of Arizona, Phoenix, College of Medicine, Department of Neurology[1]
savdeepsingh@arizona.edu

Corresponding Author

Thomas Varkey, MD
University of Arizona, Phoenix, College of Medicine, Department of Neurology[1]
Grand Canyon University, The Colangelo College of Business, Phoenix, Arizona[2]
tvarkey@utexas.edu

REFERENCES

1. Schirmer CM, Griessenauer CJ. Internal Carotid Aneurysms—Communicating Segment. *Intracranial Aneurysms*. Published online January 1, 2018:499-511. doi:10.1016/B978-0-12-811740-8.07001-5.
2. Foix C. Obliteration de l'artere choroidienne anterieure : Ramollissement cerebral, hemiplegie, hemianesthesie et hemianopsie. *Bull Soc Ophthalmol Paris*. 1925;37:221-223. Accessed March 29, 2024. https://cir.nii.ac.jp/crid/1571698599624600064.
3. Palomeras E, Fossas P, Cano AT, Sanz P, Floriach M. Anterior choroidal artery infarction: a clinical, etiologic and prognostic study. *Acta Neurol Scand*. 2008;118(1):42-47. doi:10.1111/J.1600-0404.2007.00980.X.
4. Ois A, Cuadrado-Godia E, Solano A, Perich-Alsina X, Roquer J. Acute ischemic stroke in anterior choroidal artery territory. *J Neurol Sci*. 2009;281(1-2):80-84. doi:10.1016/j.jns.2009.02.323.
5. Bruno A, Graff-Radford NR, Biller J, Adams HP. Anterior choroidal artery territory infarction: a small vessel disease. *Stroke*. 1989;20(5):616-619. doi:10.1161/01.STR.20.5.616.
6. Levy R, Duyckaerts C, Hauw JJ. Massive Infarcts Involving the Territory of the Anterior Choroidal Artery and Cardioembolism. *Stroke*. 1995;26(4):609-613. doi:10.1161/01.STR.26.4.609.
7. You R, McNeil JJ, O'Malley HM, Davis SM, Donnan GA. Risk factors for lacunar infarction syndromes. *Neurology*. 1995;45(8):1483-1487. doi:10.1212/WNL.45.8.1483
8. Hart RG. Lacunar strokes in patients with diabetes mellitus: risk factors, infarct location, and prognosis: the secondary prevention of small subcortical strokes study. *Stroke; a journal of cerebral circulation*. 2014;45(9):2689-2694. doi:10.1161/STROKEAHA.114.005018
9. Rigatelli G, Zuin M, Bilato C. Atrial septal aneurysm contribution to the risk of cryptogenic stroke in patients with patent foramen ovale: A brief updated systematic review and meta-analysis. *Trends Cardiovasc Med*. 2023;33(6):329-333. doi:10.1016/J.TCM.2022.02.006
10. Yetkin E, Ileri M, Korkmaz A, Ozturk S. Association between atrial septal aneurysm and arrhythmias.

Scandinavian Cardiovascular Journal. 2020;54(3):169-173. doi:10.1080/14017431.2019.1667525

11. Cabanes L, Mas JL, Cohen A, et al. Atrial septal aneurysm and patent foramen ovale as risk factors for cryptogenic stroke in patients less than 55 years of age. A study using transesophageal echocardiography. *Stroke*. 1993;24(12):1865-1873. doi:10.1161/01.STR.24.12.1865
12. Varkey TC, Varkey JA, Sivakumar M, Merhavy ZI. The Mongoose Phenomenon: A New Logical Heuristic. Galician med. j. [Internet]. 2022Jun.1 [cited 2024Mar.31];29(2):E202226. Available from: https://ifnmujournal.com/gmj/article/view/E202226

Certification Corner

Are you preparing for stroke certification as a Neurovascular Registered Nurse (NVRN), Advanced Neurovascular Practitioner (ANVP), Certified Neurointerventional Clinician (CNIC), or an Advanced Stroke Coordinator (ASC)? Use these questions to gauge your preparedness to test.

Part I: CNIC & ANVP Applicable Questions

1. A patient presents with a known history of chronic subdural hematoma (cSDH) that has been present for at least two months. The noncontrast CT should reveal a lesion appearing as which of the following?
    a. Isodense intra-axial lesion not crossing suture lines with homogenous blood density
    b. Hypodense intra-axial lesion not crossing suture lines with homogenous blood density
    c. Hyperdense extra-axial lesion crossing suture lines; may have mixed blood densities
    d. Hypodense extra-axial lesion crossing suture lines; may have mixed blood densities

2. You receive report on a patient awaiting transfer from a primary stroke center hospital for what has been reported as an "altered neurologic exam" following an admission for hypertensive emergency (BP 260/140 mm Hg). Only a noncontrast CT is available for review; findings implicate the need for vascular imaging of which of the following?

    a. Anterior cerebral artery
    b. Posterior cerebral artery
    c. Middle cerebral artery
    d. Internal carotid artery

Certification Corner

Part II: NVRN, ASC, CNIC & ANVP Applicable Questions

3. You receive notification that a stroke patient is on route to your hospital by ambulance from an acute stroke ready hospital (ASRH). The NIH Stroke Scale (NIHSS) score was reported as 12 and the noncontrast CT scan was read as normal by the telemedicine provider, but no other imaging has been performed. Symptoms started 30 minutes before hospital arrival, so the patient was treated by the ASRH with intravenous tenecteplase. The patient is due to arrive at your hospital at 2.5 hours from symptom onset. Based on this information, you anticipate which of the following actions when the patient arrives?
    a. Perform CT angiography (CTA) and CT perfusion imaging to determine thrombectomy candidacy
    b. Transfer the patient directly to the neurointerventional lab for thrombectomy since the NIHSS score is indicative of large vessel occlusion (LVO) stroke
    c. Transfer the patient directly to the Stroke Unit for continued care
    d. Perform CTA to determine whether the patient has an LVO

4. Aneurysmal subarachnoid hemorrhage is most commonly found in patients with which of the following characteristics?
    a. Japanese race
    b. Male sex
    c. Age ranging from 60-75 years
    d. Known history of amyloid angiopathy

5. You are asked by your stroke coordinator to calculate the ICH Score for your 72-year-old hypertensive deep subcortical hemorrhage (volume = 42 mL) patient; the Glasgow Coma Scale score is 5 and the patient has intraventricular extension. You tell the stroke coordinator that the patient's score is:
    a. 1
    b. 2
    c. 3
    d. 4

Part III: ASC Questions

6. As a stroke coordinator, your work is tied to improving practice to enhance outcomes; you recognize that understanding organizational behavior and motivation are key to successfully implementing change. Knowing this, which of the following reflects important knowledge about healthcare workers today that may impact your ability to change practice?
    a. Most workers are highly engaged in their work and the work setting.
    b. More than half of workers do not trust their employers or supervisors.
    c. Employees would be happier on the job if they were paid more money.

   d. Most managers have significant expertise in implementing change.
7. Which of the following is an example of an intrinsic motivator?
   a. Working in a healthy workplace culture that promotes honest, supportive relationships
   b. Being paid a salary that reflects workload and the special knowledge required to perform optimally
   c. Work colleagues that are kind, friendly, and fun
   d. Receiving personal recognition for one's contribution to the stroke team

Part IV: CNIC Questions

8. The Barrow Caroticocavernus Fistulae (CCF) classification is the most widely utilized system for classifying CCF; it categorizes cases:
   a. Based on the degree of venous system involvement in the anomaly.
   b. Into "direct" and "indirect" fistulas.
   c. By the presence or absence of subarachnoid hemorrhage on imaging.
   d. Similarly to systems used for dural arteriovenous fistulae (dAVF).

9. You have been asked to be a part of a work group in your neurointerventional lab that is developing policies and procedures that ensure radiation safety and protection. You know that the guiding principle for radiation protection is ALARA, which stands for:
   a. **AL**ways **A**void **R**adiation **A**rtifact.
   b. **A**void **L**ong **A**ssistance-in **R**adiographic **A**reas.
   c. **A**ll **L**ead **A**pron **R**adiation **A**rea.
   d. **A**s **L**ow **A**s **R**easonably **A**chievable.

10. The 3 sources of radiation that all workers should be shielded from in neurointerventional labs include which of the following:
   a. Directed, secondary, and discharged radiation
   b. Procedural, focused, and environmental radiation
   c. Primary, leakage, and scattered radiation
   d. Non-procedural, capitated, and errant radiation

Part V: NVRN & ANVP Questions

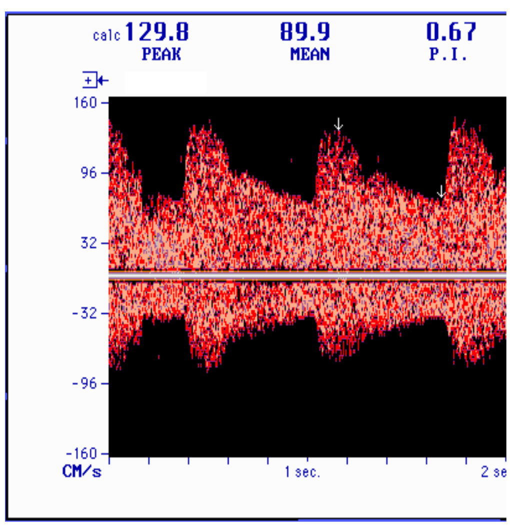
11. Which of the following was the first successful intervention to treat acute stroke disability?
   a. Tissue plasminogen activator (tPA)
   b. Aspirin 81 mg per os or per rectum
   c. Specialized stroke units
   d. Fellowship-trained vascular neurologists
12. Which of the following is true about thrombolytic agents?

a. Alteplase dosing is not affected by renal impairment, whereas tenecteplase dosing must be modified in patients with impaired renal function.
b. Tenecteplase has a shorter half-life than alteplase.
c. Tenecteplase and alteplase are both tissue plasminogen activator (tPA) agents.
d. All patients were weighed on bed or stretcher scales to determine dose in the NINDS rt-PA Stroke Study that led to approval of alteplase for ischemic stroke treatment.

13. You are caring for a patient with a 38-pack year history of smoking who has recently been admitted with a first-ever ischemic stroke. He is awake and oriented to time, place and person, with no language deficits and minimal 4/5 left arm and left lower facial weakness after treatment with tenecteplase; his score on the *Readiness to Quit Ladder* is 2. In preparing to provide smoking cessation counseling you know that which of the following are important considerations?
    a. Previous quit attempts should be viewed as failures and not used to motivate behavioral change
    b. Menthol cigarettes carry a higher stroke risk than non-menthol brands, making this important information to impart
    c. The importance of a "cold turkey" quit approach should be emphasized, with complete abstinence once the patient leaves the hospital
    d. Physiologic dependence on nicotine typically lasts up to 3 months; quit dates for complete abstinence should be set after this time

Part VI: ANVP Questions

14. Which of the following is true about the transcranial Doppler waveform below?



a. The waveform represents reverberating flow classically seen in patients progressing to brain death.
b. The image is suggestive of vasospasm warranting angiography.
c. There is high resistance to forward flow, suggesting markedly increased intracranial pressure.
d. The waveform reflects a low-pressure state with normal mean flow velocities.

15. You are caring for a 39-year-old father of two young children that was transferred to your comprehensive stroke center 16 hours after total left hemispheric cerebral infarction due to traumatic dissection of the internal carotid artery. Because the patient was positive for alcohol at the time of his initial presentation to a small community hospital, his neurologic changes went undiagnosed and were assumed to be due to alcohol intake. He presents now at your comprehensive stroke center (CSC) with lethargy, and an NIH Stroke Scale (NIHSS) score of 21: Item 1A = 1; Item 1B = 2; Item 1C = 2; Item 2 = 2; Item 3 = 2; Item 4 = 2; Item 5 = 3; Item 6 = 3; Item 7 = 0; Item 8 = 1; Item 9 = 2; Item 10 = 1; 11 = 0. Imaging repeated at your CSC shows no midline shift or evidence of herniation on imaging. Which of the following is the most evidence-based approach to optimizing outcome for this patient and his family?
    a. Providing therapeutic hypothermia (33-degrees C) to reduce metabolic demands and provide neuroprotection.
    b. Discussing transfer to palliative care services since quality of life is extremely poor in patients with total left hemispheric stroke.
    c. Immediate transfer to the operating suite for left decompressive hemi-craniectomy.
    d. Beginning serial NIHSS assessments with STAT repeat imaging for further deterioration, and immediate notification of neurosurgery for worsening.

Part I: Answers

1. **D**. Chronic subdural hematoma (SDH) appears hypodense and may have mixed layers of blood density within it from recurring bleeding intervals. Subacute SDH appears isodense, whereas acute SDH appears hyperdense. SDH crosses suture lines, whereas epidural hematomas (EDH) do not because of fusion of the dura to the calvarium at the margins of the sutures. Both SDH and EDH are extra-axial lesions.
2. **D**. The noncontrast CT shows a watershed infarction; these are strokes that occur “between arterial territories” that result from severe large artery hemodynamic compromise, in this case due to near occlusion of the right internal carotid artery. Hypertensive emergency as a presenting symptom was likely due to the patient’s underlying hypertension diagnosis in combination with near occlusive stenosis; aggressive antihypertensive treatment resulted in a significant reduction of blood flow to the far distal aspects of the middle and anterior cerebral arterial territories resulting in the watershed infarction.

Certification Corner

Part II: Answers

3. **D**. The patient should undergo CT angiography (CTA) of the aortic arch, neck, and head to rule in/out large vessel occlusion (LVO) stroke. Although the NIH Stroke Scale (NIHSS) score is 12, this does not guarantee the presence of an LVO; additionally, CTA provides important information that can assist interventionalists with vascular system catheter navigation. The patient does not warrant the need for CT perfusion (CTP) given that he is only 2.5 hours from symptom onset, and since CTP can overcall infarction, many physicians favor determining tissue viability by review of the noncontrast CT alone.
4. **A**. The Japanese carry the highest incidence of aneurysmal subarachnoid hemorrhage (aSAH) in the world. Females have a higher incidence of aSAH than males, and age range is most commonly around 50 years. Amyloid angiopathy is closely associated with intracerebral hemorrhage, but not aSAH.
5. **C**. The patient is under 80 years of age (score = 0), with a hemorrhage greater than 30 mL (score = 1), a Glasgow Coma Score of 5 points (score = 1), a supratentorial hemorrhage (score = 0) and intraventricular extension (score = 1 point).

Part III: Answers

6. **B**. Unfortunately, trust is currently a key issue for healthcare workers, and when changing approaches to how care has been traditionally provided, stroke coordinators should know that trust comes further into question. Employee engagement today is poor, and employees that are unhappy on the job rarely report salary as the key issue. Complicating things further, most people in managerial positions lack expertise instituting change in a positive manner.
7. **D**. Intrinsic motivators come from within the individual and are a powerful stimulus for motivation. Extrinsic motivators can also be powerful for employees and contribute to work environment culture.

Part IV: Answers

8. **B**. The Barrow Classification divides caroticocavernous fistulas into direct (type A) or indirect (types B-D). Type A fistulas are the most common, with a direct connection between the intracavernous internal carotid artery (ICA) and the cavernous sinus. Type B fistulas have a dural shunt between the meningeal branches of the intracavernous ICA and the cavernous sinus. Type C fistulas have a dural shunt between meningeal branches of the external carotid artery (ECA) and the cavernous sinus. Type D fistulas have a dural shunt between both meningeal branches of the intracavernous ICA and the meningeal branches of the ECA with the cavernous sinus. Others have proposed an alternative classification based on venous drainage, but this is not widely utilized.
9. **D**. Radiation levels should always be set as low as possible while still producing good quality imaging that supports clinical and treatment decision making.
10. **C**. Primary radiation is that which comes from the x-ray source, whereas secondary radiation is created when the primary beam interacts with matter; scatter radiation is considered a form of secondary radiation that results when the x-ray beam is deflected from its path by interaction with matter.

Certification Corner

Part V: Answers

11. **C**. In 1991, stroke patients that received care on specialized stroke units were first shown to have significantly lower rates of disability and death, compared to those cared for on general care or mixed units, well before approval of alteplase tissue plasminogen activator (tPA). Numerous studies since that time continue to show significant reductions in both disability and death for patients cared for on specialized stroke units. Aspirin is not a disability reducing stroke treatment, and while vascular neurologists have played an important role improving acute and ongoing preventive care for stroke, they are a relatively new specialty and not themselves a treatment for stroke.
12. **C**. Tenecteplase, alteplase, and even reteplase are all types of tissue plasminogen activators (tPA); because of this, when tPA is written in a medical record, the provider should state "alteplase tPA" or "tenecteplase tPA." Both tenecteplase and alteplase do not require special dosing for renal impairment, and alteplase has a shorter half-life making it require dosing with both a bolus and an hour-long infusion. In the NINDS rt-PA Stroke Study and all other clinical trials of alteplase tPA approval, patients were not weighed to determine dose; dose was estimated or calculated from available information (e.g. drivers licenses) because bed/stretcher scales did not exist at the time of these studies meaning we can be assured that these methods also produce safe dosing and effective treatment results.
13. **B**. Recent data have shown higher risk for stroke with menthol cigarettes. Previous quit attempts signal a patient that is motivated and wants to quit smoking; these should be discussed to determine what caused the attempt to fail. Cold turkey methods carry low success rates for smoking cessation. Physiologic dependence on nicotine generally concludes by 2 weeks, whereas behavioral dependence can last quite some time.

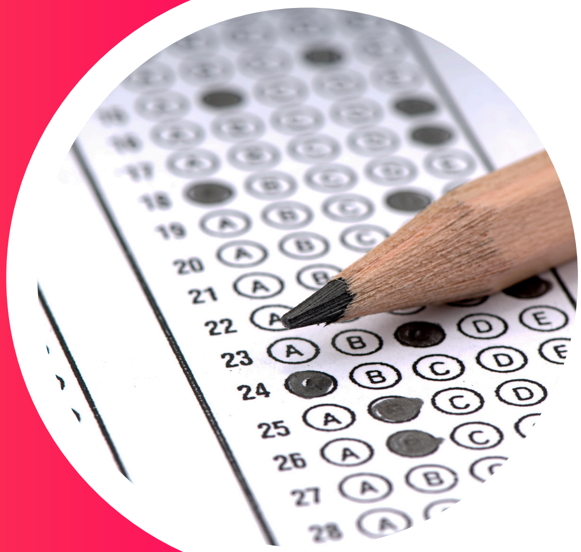
Part VI: Answers

14. **D**. The waveform is normal with low resistance flow as reflected by both the pulsatility index (PI) and the generous diastolic flow. The waveform is bidirectional showing both the middle cerebral artery (MCA) blood flow and the anterior cerebral artery blood flow at the bifurcation. The MCA flows toward the probe (positive waveform) with its normally higher mean flow velocity (MFV), while the ACA flows away from the probe (negative waveform) with a lower MFV.
15. **C**. While decompressive hemicraniectomy is lifesaving, it is not always disability reducing; however, many patients go on to experience meaningful happy lives. A nihilistic approach that advocates for palliation does take into consideration the needs of a young conscious (although lethargic) patient with young children. Attempts to discuss surgical treatment should be made by the team. Waiting and watching for deterioration is not recommended because when hemicraniectomy is undertaken, the results are best when patients have not yet worsened. While therapeutic hypothermia is sometimes used as a last-ditch effort, it has yet to be proven as a method to decrease disability.

Certification Corner

Are you an NVRN, ANVP, ASC, or CNIC board certified clinician and interested in writing test items for the Neurovascular Clinicians Certification Corporation (NVC-3)? Contact info@anvc.org at your earliest convenience to learn how to contribute!

Neurovascular Clinicians Certification Corporation



Greenville, SC
May 19
Prismahealth
Upstate Hospital

ANVC
Conference
November 14
The Woodlands, TX

Free For All

Must be an in-person paper exam at one of our onsite testing opportunities

www.anvc.org/nvc-3

The Royal University Hospital, Acute Stroke Unit

Ruth Whelan, MSN, RN, ANVP-BC[1]

Saskatchewan is a province in Western Canada with a population of 1.17millon people. The province has 651,900 km^2 (405,072 miles) of rolling prairie, boreal forests, and numerous lakes. There are 8 primary stroke centers (PSC) across the province, which all connect with a single comprehensive stroke center (CSC) in a hub and spoke model. Emergency medical personnel use the locally modified and validated FAST VAN stroke screen to direct patient transfer to the most appropriate center for acute stroke care. In this way, patients may bypass PCSs to go directly to the CSC when a large vessel occlusion is suspected.

In this issue of *Stroke Clinician*, we proudly present the Acute Stroke Unit located in Saskatoon at the Royal University Hospital (RUH) CSC. The Saskatoon Stroke Program has been successful in earning Stroke Distinction through *Accreditation Canada*[1] by showing evidence of excellence in stroke care delivery (Photo 1). Having an acute stroke unit is one of the greatest determinants for attainment of this important accreditation.

Stroke units are characterized by a core team of interprofessional practice members caring for stroke patients that are segregated within a geographically defined space.[2] Numerous studies have shown that patients who receive care on a designated stroke unit have decreased complication rates, lower mortality, better functional outcomes and are more likely to return home.[2-6]

Photo 1: Stroke Distinction award photo collage.

Our RUH Acute Stroke Unit (ASU) has 14 designated stroke beds with 6 of these being high-acuity stroke beds. The ASU is supported by the LEAN methodologies quality framework, with standards of care reflecting the *Canadian Stroke Best Practice Recommendations (CSBPR)*.[7] These key recommendations guide the evolution ASU policies, practices, and quality performance measures.

Patients admitted to RUH with a diagnosis of stroke or high-risk transient ischemic attack are admitted to the ASU following their hyperacute emergency care period. With the 6 high acuity beds, patients can be monitored on the ASU directly following tenecteplase (TNK) administration or post thrombectomy. The ASU is led by an interprofessional practice (IPP) team that includes dedicated neurovascular nurses educated and clinically trained in acute stroke monitoring and care, vascular neurologists, a clinical nurse specialist (author), a nurse coordinator, physiotherapists, occupational therapists, speech and language pathologists, a clinical dietitian, a social worker, a clinical pharmacist, a recreational therapist, and a discharger planner (Photo 2). Palliative care specialists support the team as ad hoc members.

Photo 2: Acute Stroke Unit interprofessional team members. Royal University Hospital, Saskatoon, Saskatchewan, Canada. (Author on the bottom row at far right.)

Pre-populated evidence-based stroke-specific order sets are used for most aspects of stroke management, including TNK administration, post thrombectomy care, and workup for stroke pathogenic mechanism. Evidence-adherent management strategies are used to aid in the optimization of recovery, complication avoidance, and individualized secondary stroke prevention. The IPP team works together to ensure care plans are individualized, addressing nutrition, bowel and bladder function, skin protection or breakdown, visual dysfunction, and dysphagia.

Each day, the IPP team meets in a structured "bullet rounds" to discuss all stroke patients on the service. Bullet rounds are a key part of our commitment to ongoing quality monitoring and improvement, with content that includes review of each patient's new and pending diagnostic test results, the current management plan in relation to the therapies provided, and patients' individualized needs for transitions in care. Formal quarterly meetings are held providing an opportunity for IPP team members to reflect on their shared vision for the ASU, and to discuss ideas and review emerging evidence for necessary updates in practice. The standing agenda includes an update of current and future initiatives as well as presentation and discussion of quality performance metrics.

The ASU has had success in implementing a number of patient-centered initiatives. For example, an "Aphasia Club," was initiated by the speech language pathologist (SLP) team (Photo 3). Stroke team members also completed a "supported conversation" course provided by the Aphasia Institute.[8]

Photo 3: Aphasia Club of the Royal University Hospital's Acute Stroke Unit.

Our SLPs also implemented the Yale Bedside Swallow Screen in the ASU and emergency department to ensure a standardized approach to swallow assessment. Use of Yale Bedside Swallow Screen has now been implemented across the entire province at stroke hospitals.

Our Post-Stroke Visual Impairment (PSVI) Clinic is another example of a successful

In Our Stroke Unit

ASU initiative. A local orthoptist and ASU occupational therapists work collaboratively in the PSVI Clinic using evidence-based standardized approaches to support patients with visual deficits. We also developed and implemented a terminal care neurological palliative care pre-populated order set by collaborating with the palliative care team to ensure provision of standardized care and information delivery to patients' significant others. Our IPP team leader also hosts a virtual, provincial monthly grand rounds for stroke clinicians in PSCs and rural facilities that covers important topics in stroke management across the care continuum.

Segregating stroke patients together on our ASU ensures continuity of evidenced-based stroke-specific care. Ultimately, the IPP specialist team approach ensures optimal patient outcomes and speeds stroke recovery.

Author Affiliations

Ruth Whelan is the clinical nurse specialist for the Royal University Hospital's Acute Stroke Unit in Saskatoon, Saskatchewan, Canada, and a member of the ANVC Leadership Development Committee.

References

1. Accreditation Canada. Accreditation Canada - Healthcare Accreditation Body. Accessed April 20, 2024.
2. Langhorne P, Ramachandra S; Stroke Unit Trialists' Collaboration. Organised inpatient (stroke unit) care for stroke: network meta-analysis. Cochrane Database Syst Rev. 2020 Apr 23;4(4):CD000197. doi: 10.1002/14651858.CD000197.pub4. PMID: 32324916; PMCID: PMC7197653.
3. Langhorne P, Ramachandra S; Stroke Unit Trialists' Collaboration. Organized Inpatient (Stroke Unit) Care for Stroke: Network Meta-Analysis. Stroke. 2020 Dec;51(12):e349-e350. doi: 10.1161/STROKEAHA.120.030825. Epub 2020 Nov 23. PMID: 33226929.
4. Urimubenshi G, Langhorne P, Cadilhac DA, Kagwiza JN, Wu O. Association between patient outcomes and key performance indicators of stroke care quality: A systematic review and meta-analysis. Eur Stroke J. 2017 Dec;2(4):287-307. doi: 10.1177/2396987317735426. Epub 2017 Oct 5. PMID: 31008322; PMCID: PMC6453192.
5. Langhorne P, Fearon P, Ronning OM, Kaste M, Palomaki H, Vemmos K, Kalra L, Indredavik B, Blomstrand C, Rodgers H, Dennis MS, Al-Shahi Salman R; Stroke Unit Trialists' Collaboration. Stroke unit care benefits patients with intracerebral hemorrhage: systematic review and meta-analysis. Stroke. 2013 Nov;44(11):3044-9. doi: 10.1161/STROKEAHA.113.001564. Epub 2013 Sep 24. PMID: 24065713.
6. Stroke Unit Trialists' Collaboration. Organised inpatient (stroke unit) care for stroke. Cochrane Database Syst Rev. 2000;(2):CD000197. doi: 10.1002/14651858.CD000197. Update in: Cochrane Database Syst Rev. 2002;(1):CD000197. PMID: 10796318.
7. *Canadian Stroke Best Practice Recommendations.* Heart and Stroke Foundation of Canada | Home accessed April 20, 2024.
8. Aphasia Institute. https://www.aphasia.ca/. Accessed April 20, 2024.

Official Journal of the Association of Neurovascular Clinicians

STROKE CLINICIAN

ANVC is excited to announce its official journal, ***Stroke Clinician***! The Journal is focused exclusively on publication of clinically relevant papers that cover all aspects of neurovascular disease practice and are of interest primarily to non-physician clinicians and stroke administrators. Relevant content should focus on any of the following subject areas:

- Primary or secondary stroke prevention topics
- Stroke emergency management
- Innovative strategies for organizing stroke care or stroke programs
- Acute diagnosis and interprofessional management topics in patients with ischemic or hemor- rhagic stroke including neurocritical care of stroke patients
- Complication avoidance and complication management in stroke patients
- Transitions in stroke care across the continuum
- Stroke center certification preparation
- Stroke program quality improvement projects
- Educational preparation of stroke clinicians and/or stroke patients
- Stroke practice protocols and methods to standardize practice
- Innovative stroke unit organization and structure

Scan this QR code to submit your publication, or learn more about the Journal.