Is There a Neurologist in the House? A Summary of the Current State of Neurovascular Rotations for Emergency Medicine Residents

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ABSTRACT

Objectives: Neurovascular and neurocritical care emergencies constitute a leading cause of morbidity/mortality. There has been great evolution in this field, including but not limited to extended time-window therapeutic interventions for acute ischemic stroke. The intent of this article is to evaluate the goals and future direction of clinical rotations in neurovascular and neurocritical care for emergency medicine (EM) residents.

Methods: A panel of 13 board-certified emergency physicians from the Society for Academic Emergency Medicine (SAEM) neurologic emergencies interest group (IG) convened in response to a call for publications—three with fellowship training/board certification in stroke and/or neurocritical care; five with advanced research degrees; three who have been authors on national practice guidelines; and six who have held clinical duties within neurology, neurosurgery, or neurocritical care. A mixed-methods analysis was performed including a review of the literature, a survey of Council of Emergency Medicine Residency Directors (CORD) residency leaders/faculty and SAEM neuro-IG members, and a consensus review by this panel of select neurology rotations provided by IG faculty.

Results: Thirteen articles for residency neurovascular education were identified: three studies on curriculum, three studies evaluating knowledge, and seven studies evaluating knowledge after an educational intervention.

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Intervention outcomes included the ability to recognize and manage acute strokes, manage intracerebral hemorrhage, calculate National Institutes of Health Stroke Scale (NIHSS), and interpret images. In the survey sent to CORD residency leaders and neuro-IG faculty, response was obtained from 48 programs. A total of 52.1% indicated having a required rotation (6.2% general neurology, 2% stroke service, 18.8% neurologic intensive care unit, 2% neurosurgery, 22.9% on a combination of services). The majority of programs with required rotations have a combination rotation (residents rotate through multiple services) and evaluations were positive.

Conclusions: Variability exists in the availability of neurovascular/neurocritical care rotations for EM trainees. Dedicated clinical time in neurologic education was beneficial to participants. Given recent advancements in the field, augmentation of EM residency training in this area merits strong consideration.

Neurologic disorders are a significant cause of morbidity and mortality worldwide. Globally, neurologic disorders are the second leading cause of death (16.8%) and the leading cause of disability-adjusted life-years.¹ Neurologic complaints make up a significant proportion of all emergency department (ED) visits, comprising over 5% of total visits across United States EDs.² Emergency physicians (EPs) encounter a broad spectrum of life-threatening neurovascular and other neurocritical care conditions, ranging from ischemic and hemorrhagic stroke to traumatic brain injury and status epilepticus. EPs play a vital role in the acute evaluation and administration of time sensitive interventions in many of these life-threatening neurologic emergencies.

The past decade has seen an explosion of novel and innovative approaches to managing and treating acute neurovascular and neurocritical diseases. From the creation of neurocritical care as a subspecialty with emergency medicine (EM) eligibility for fellowship to the creation of acute stroke ready, primary, thrombectomy-capable, and comprehensive stroke centers, EPs stand at the forefront of these advances in neurologic emergencies. Furthermore, advances over the past decade in the management of common life-threatening neurologic emergencies, such as ischemic stroke, have resulted in recent changes in the guidelines and evidence-based recommendations for the management of neurologic emergencies in the ED.³ Many of these novel treatments, such as thrombectomy for large-vessel occlusions and the introduction of the extended window for thrombolysis, rely significantly on the timely clinical assessment and management by EPs, making the effective training of EPs in the evaluation and management of this diverse range of neurologic emergencies critical to the success of patient outcomes.

In spite of the advances and evolution in our understanding of the treatment of neurologic emergencies, formal training in neurologic emergencies among EM residency-trained EPs appears limited and the

extent of such training availability is variable. Among EM residency programs in the United States, 34.7% have a required neurology or neurosurgery rotation.⁴ Of those requiring such a rotation, only one-half require time in the neurologic intensive care unit (NICU). Overall, residency programs maintain a mean of 12.0 ($\pm$ 5.9) hours of lecture hours focused on neurologic emergencies annually, making up 4.6% of the total Accreditation Council for Graduate Medical education requirement of the 260 annual hours of educational experiences outside of clinical duties.⁴ These data are from over a decade ago, prior to many of the recent advances in neurologic diagnostic tools and treatments for stroke and may not reflect current educational trends or patterns; however, they emphasize that at least historically, neurologic education in EM training programs may not have been adequate. The potential consequences of a lack of adequate training in neurologic emergencies include difficulties in performing the key components of the acute examination, due to lack of experience or knowledge, delays in identifying acute neurologic emergencies, and the potential for suboptimal management and care of these critically ill and time sensitive patients.

The overarching goal of this panel's concept paper is to initiate a conversation regarding current approaches to neurologic education among EM training programs. More specifically, the aim is to evaluate the current state of neurovascular and neurocritical care clinical rotations for EM residents by performing the following objectives:

1. To gather data on existing neurovascular curriculums in EM residency programs through the completion of a narrative literature review.
2. To identify the current methods in which EM residents are engaged in neurovascular and neurocritical care (NICU) rotations as part of their clinical curriculum.
3. To examine advantages of a resident focused stroke and/or NICU rotation.

4. To define and propose a model in which to structure key educational objectives for EM stroke and NICU resident rotations.

METHODS

This was a mixed-methods study performed by academic EM faculty from the Society for Academic Emergency Medicine (SAEM) Neurology Interest Group (SNIG) designed to establish the current state of neurovascular education among EM residencies in United States. The panel consisted of 13 board-certified EPs—three with fellowship training/board certification in stroke and/or neurocritical care, five with advanced research degrees, three who have been authors on national practice guidelines, and six who have held clinical duties within neurology, neurosurgery, or neurocritical care. First, a narrative review of the current published articles and abstracts on neurology education for EM residents was conducted. Second, a survey was sent to Council of Emergency Medicine Residency Directors (CORD) residency leaders to determine the level of stroke certification of their hospitals and availability of neurovascular and NICU rotations on the programs. Third, commentaries and feedback from EM residents who rotated in NICU or stroke programs was obtained. Finally, the fourth part of this article summarized of considerations from our focus group with regards to stroke and NICU rotations that may serve as a template for programs looking to start such rotations.

Literature Review Methods

This is a narrative review; the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were followed.⁵

Eligibility. All study designs, including cross-sectional, prospective, retrospective and interventional studies; randomized controlled trials; editorials; letters; and qualitative studies on the topic of neurovascular education for EM residents were eligible. Studies not related to neurovascular education or not related to resident physicians were excluded.

Search. A librarian performed the literature search in the following databases: OVID MEDLINE (from 1946 to June week 4, 2018) and EMBASE (from 1988 to week 27, 2018). Studies were limited to human and English language. The complete search

strategy is in Data Supplement S1, Appendix 1 (available as supporting information in the online version of this paper, which is available at <http://onlinelibrary.wiley.com/doi/10.1002/aet2.10200/full>).

Study Selection and Data Collection. Two of the authors independently reviewed studies to identify studies that met the above criteria, and any disagreements were resolved by consensus. Agreement on article selection between reviewers was calculated, and kappa was reported. Some studies were only described in abstracts/conference proceedings; in these cases, study authors were contacted to determine whether full-text manuscripts had been subsequently published. Data extraction tables were used to extract the main finding and characteristics of each of the included studies. Both quantitative and qualitative studies were included and summarized in tables to help contextualize the evidence. Qualitative studies were defined as: 1) aims did not include the extraction of quantitative outcomes and statistical analysis was not utilized; 2) original research is presented; and 3) qualitative research methods were applied, including semistructured and unstructured interviews, open-ended survey questions, focus groups, and examination of records and documents.⁶

Synthesis of Results. After relevant studies were identified, a data-driven thematic analysis was performed. Quality and risk of bias of the included studies were not assessed, as this was intended to be a narrative review only.

CORD Survey Methods

Survey Content. A survey was developed for residency leaders in EM and key neuroscience EM faculty. Questions included level of hospital stroke certification, availability of stroke and NICU rotations, and availability of required and elective neurology-related rotations. Surveys were anonymous; however, the institution represented by each respondent was recorded to avoid reporting of duplicate information (i.e., two individuals from the same institution answering the survey).

Development and Testing. The questions were developed and refined by members of the SNIG. The survey was developed and distributed electronically using SurveyMonkey. All the questions and the format were reviewed and refined by the coinvestigators.

Survey Distribution. In July 2018, CORD residency leaders and faculty, along with the SNIG membership, were invited by e-mail to participate in a five-question survey; an additional program identification question was included to prevent duplicative results. Participation was voluntary; no incentives were given to participants, and one e-mail request was sent. A copy of the electronic survey is in Data Supplement S1, Appendix 2.

Commentaries/Feedback from EM Residents Methods

Commentaries and feedback from a convenience sample of EM residents who had rotated in required NICU or stroke programs and/or electives were requested through personal e-mail communication at two academic institutions. Responses regarding the value of the rotation and key learning areas were summarized.

Specific Considerations From SNIG Methods

A summary of considerations from a focus group with regards to stroke and NICU rotations was performed,

with multiple members providing sample anonymous stroke and NICU rotation descriptions at their sites. The work structure and educational objectives of these rotations were presented to the panel, collated, and summarized.

RESULTS

Literature Review Results

The librarian search yielded 56 titles and abstracts for review. Duplicates were culled, 27 were pulled for full-text review, and 13 were selected for inclusion in the literature review. There was strong agreement between reviewers ($\kappa = 0.852$, $SE = 0.10$) with regard to selection of articles (see Figure 1 for literature search flowchart).

A total of 13 articles were selected (Table 1), representing residency training in different countries including United States, United Kingdom, Canada, Finland, and Ireland. Four were conference abstracts, two were letters to the editor, and seven were full manuscripts. Regarding study design, six were surveys regarding

Figure 1. Flow chart of the selected articles.

Table 1
Summary of Included Articles on Neurology Education for EM Residents

Author	Year	Country	Study Type	Study Population	Intervention	Outcome/Results
<i>Studies Regarding Curriculum</i>						
Harris	2016	Canada	Survey	20 program directors from Canadian EM residency programs	NA	Limited formal training—2/20 programs had mandatory stroke neurology rotations; 3 hours of stroke-related lectures per year.
Stettler	2005	United States	Survey	92 program directors	NA	Required neurology rotation for 17.4% of programs; neurosurgery rotation required for 14 programs; electives available in 32 programs (neurology, neurosurgery, or neuroradiology) but “seldom used.” Mean of 12 hours per year devoted to neurologic emergencies.
Martin	1993	United States	Commentary	NA	NA	List of objectives/goals for neurologic curriculum for EM residents based on ACEP core content.
<i>Studies That Evaluate Knowledge of Residents After an Educational Intervention</i>						
Bambrick	2017	Ireland	Educational intervention/survey	39 residents (including 13 EM)	Educational intervention of hyperacute stroke treatment pathway	Improvement in awareness of tPA time window, door-to-CT time, increase in prenotification.
Frallicciardi	2015	United States	Educational intervention/simulation/survey	36 EM interns	Completion of NIHSS online and simulation/debriefing	Improved knowledge, confidence, and efficiency in diagnosis and treating acute stroke including ordering CT, tPA, and assessing NIHSS.
Stegmaier	2014	United States	Educational intervention/survey	28 EM residents	Lecture on NIHSS and practice with two patients	Ability to perform NIHSS: resident score was within 2 points of certifier score in 50% of examinations.
Rodriguez	2014	United States	Educational intervention/survey	EM residents taught by residents from neurology and neurosurgery (20% EM resident response rate)	Interdisciplinary conference with lectures, small groups, problem-based scenarios, resident to resident teaching	Interdisciplinary resident-to-resident teaching was a reasonable and effective approach to teaching EM residents.
Perron	1998	United States	Educational intervention/survey	83 EM residents	2-hour course on reading CT scans	Mean scores improved from 60% correct prior to intervention to 78% after intervention, $p < 0.001$.
Garside	2012	United Kingdom	Simulation/educational intervention/survey	192 junior doctors and nurses	1-day intervention of patient videos/simulated stroke scenarios	Median confidence in assessing stroke and TIA increased between pre and post assessments, confidence regarding preparation for thrombolytic increased.
Halinen	2016	Finland	Cohort study	Acute stroke patients receiving tPA by EM doctors vs. neurologists	Educational intervention to give thrombolytic to acute strokes	Number of patients receiving tPA increased, door-to-needle time decreased.
<i>Studies That Evaluate Knowledge of Residents Not Associated With an Intervention</i>						
McIntyre	2016	Canada	Survey assessing knowledge of use of OAC for stroke risk in those with atrial fibrillation	137 EM residents	NA	Residents favored warfarin over OAC, prioritized minimizing risk of adverse events when prescribing OAC.

(Continued)

Table 1 (continued)

Author	Year	Country	Study Type	Study Population	Intervention	Outcome/Results
Pulido	2013	United States	Survey	302 EM residents	NA	75.6% reported experience with patient who received tPA for ischemic stroke, 90.7% of respondents agreed with giving IV tPA within 3 hours, while 53% agreed within the 4.5-hour window.
Kunnel	1999	United States	Survey	701 EM residents	NA	34.1% had experience taking care of tPA patient; 73% of people considered knowledge of thrombolytics to be very good or somewhat good, 26.7% thought knowledge was weak about tPA; 44% knew ICH risk associated with tPA.

ICH = intracerebral hemorrhage; NIHSS = National Institutes of Health Stroke Scale; OAC = oral anticoagulant; tPA = tissue plasminogen activator.

current practices, and five surveys assessed a brief educational intervention like simulation training. One cohort study compared time to tPA, safety, and outcomes in the EPs management of acute stroke. Two studies involved the use of simulation for training on neurovascular pathology.

Studies Regarding Curriculum. There were three studies regarding curriculum. Harris et al.⁷ presented a summary of stroke education in Canadian EM residency programs. There are 3 hours of acute ischemic stroke lecture time per year, and mandatory general neurology and stroke neurology rotations were offered in a minority of programs. Stettler et al.⁴ surveyed program directors of EM residency programs and found that programs reported a mean of 12 hours of didactic hours each year on neurologic emergencies. Seventeen percent of programs had required rotations in neurology or neurosurgery. Martin et al.⁸ describe a list of learning objectives for EM residency curricula. These include mastery of conditions, such as stroke and a variety of other neurologic disorders. All the studies reported their program's curriculum experience. None of the studies defined the most effective ways to incorporate such content into academic curricula or neurology rotations for EM residents.

Studies That Evaluate Knowledge of Residents After an Educational Intervention. There were seven studies that evaluated the knowledge of residents after an educational intervention. Bambrick et al.⁹ showed an improvement in awareness of local

and international guideline recommendations, as well as an improvement on best practice approaches like ambulance prealert and immediate stroke specialist contact. Frallicciardi et al.¹⁰ reported a blended curriculum of medical simulation and e-learning; in the simulated scenario, time to CT and tPA orders improved. Stegmaier et al.¹¹ found that immediate feedback on examination technique for National Institutes of Health Stroke Scale (NIHSS) and practice on real patients was better than online training modules. Rodriguez et al.¹² reported that an interdisciplinary stroke conference with resident-to-resident teaching across multiple specialties was an effective approach to delivering clinical information to resident learners. Perron et al.¹³ reported improvement on CT interpretation after a 2-hour educational session. Garside et al.¹⁴ found that learners' confidence in assessing stroke patients and in preparing for thrombolysis increased significantly after a 1-day simulation-based training. Hälinen et al.¹⁵ concluded that EM resident physicians' administration of thrombolytics for acute ischemic stroke is feasible and shortens time to treatment compared to neurologists.

All the studies reported positive results after the educational interventions. Educational methods included simulation, lectures, patient examinations, and e-learning.

Studies That Evaluate Knowledge of Residents Not Associated With an Intervention. There were three studies that evaluated knowledge of residents through surveys, not associated with an educational intervention. McIntyre et al.¹⁶ assessed knowledge regarding novel oral anticoagulants and warfarin use in

different case scenarios. Pulido and Simpson¹⁷ and Kunnel and Heller¹⁸ evaluated EM residents' knowledge, attitudes, and experiences with IV tPA for stroke.

CORD Survey Results

A convenience sample of 52 individuals answered the electronic survey with 48 responses reviewed, four excluded due to program duplication. Of the responding programs the majority have a Joint Commission Comprehensive Stroke Center designation. The majority do not have a stroke service rotation for EM residents and only half have a NICU rotation exposure. Many programs do not have required or elective neuroscience rotations available for EM residents. The majority of programs with required rotations have a combination rotation where the resident will rotate through more than one of the neuroscience services. This is also true of programs with electives. There is a subset of programs that have the ability for residents to rotate in the neurosciences without a formal rotation designation (see Table 2).

Commentaries/Feedback From EM Residents

Table 3 represents pooled and anonymous qualitative commentaries and feedback from EM residents at two panelists' institutions for stroke service and NICU electives.

Specific Considerations From SNIG

Tables 4 and 5 represent the pooled structure, content, and objectives of stroke service and NICU rotations from the curriculums of such rotations at three panelists' institutions. A copy of the ACGME core competencies applied to EM neurovascular education, expectations, and feedback from a NICU rotation are presented in Data Supplement S1, Appendix 3.

DISCUSSION

Despite significant advances in treatment for common acute neurovascular and neurocritical diseases, similar, standardized advancements in neurologic education have not been seen among EM residency programs. Neurovascular and neurocritical care emergencies are routinely encountered in the ED setting. With the significant evolution in these fields, including but not limited to advancements in neurocritical care, a greater clinical emphasis on EM phase stroke systems, the

Table 2

Faculty and Program Survey Results (Total Number Residency Programs Included = 48)

Category and Response	Program Count (N)	Percentage of Program Respondents
Joint Commission stroke center designation		
Comprehensive stroke center	42	88
Primary stroke center	4	8
No stroke center designation	2	4
Stroke service rotation available		
Yes	15	31
No	33	69
Neurocritical care rotation available		
Yes	24	50
No	24	50
Required rotation		
General neurology	3	6
Stroke service	1	2
Neurocritical care	9	19
Neurosurgery	1	2
Combination of services	11	23
None	23	48
Elective rotation		
General neurology	4	8
Stroke service	3	6
Neurocritical care	2	4
Combination of services	9	19
None	21	44
Ability to rotate	9	19

Combination of services = residents spend time on a combination of listed services; ability to rotate = resident can rotate on these services, but there is not a formal required rotation or elective.

increased utilization of telemedicine (a virtual rather than in-person consult by neurology), newer generation diagnostic imaging modalities, and enhanced therapeutic interventions, EM providers need to be well versed in disease identification and time-sensitive interventions. Additionally, with the extended time window for treatment of acute stroke there is a corresponding increase in the volume of "acute stroke patients" seen in the prehospital and ED environments. The effects of this seismic shift will become more evident in the future, but it is reasonable to consider that the specialty of EM will be a central and critical figure to the continued success of acute diagnosis, management, and initiation of interventions.

This reality necessitates the provision of enhanced educational resources to arm current era EM residents with the tools necessary for diagnosing and managing acute neurovascular and neurocritical care emergencies. Nationally, for improving the quality of care,

Table 3
Resident Evaluations of NICU and Stroke Service Rotations

	NICU Rotation	Stroke Service Rotation
Clinical skill augmentation	"Experience with neurologic exam supervised by experts."	"Great way to review neuro exam, anatomy, and stroke syndromes."
	"An opportunity to master your neuro examination."	"Perform neuro exams like HINTS with actual neurologist and see what they see."
	"It was beneficial to see a neurologist's neurological exam and how a neurologist looks for signs of seizure."	"Doing the neuro exams and correlating findings to lesions and verifying findings with the neurologist was something that couldn't be done in simulation or didactics."
		"See patients with abnormal exams and learn the corresponding diagnoses."
Key disease entities seen	ICH, SAH, SDH, epidural hematoma, AIS, posterior circulation stroke	AIS, TIA, ICH
	Carotid/vertebral artery dissection	Cerebrovascular dissections
	PRES, neuromuscular disease (GBS, MG)	Central retinal artery occlusion
	Status epilepticus, meningitis	Spinal cord stroke
	Arsenic poisoning, autoimmune encephalitis	
Clinical exposure and decision making	"Assessments of patients with rare/uncommon but don't miss neurologic disorders."	"Follow your stroke patients and see results of treatments."
	"Experienced every neuro emergency while rotating for the month."	"Have informed discussions about treatment modalities and outcomes with patients and families."
	"Clearly painted the picture of the patient with increased ICP and learned emergent treatment."	"Seeing the outcomes of stroke patients is something we often do not see in the ED."
	"In-depth exploration of lyse/no-lyse (and now yes/no for endovascular) decisions in possible acute strokes."	"Reviewing neuro radiology ourselves is something seldom done in the ED and not taught."
		(Re: telemedicine) "It did strike me what a challenge it can be to interpret a neuro exam you're not performing."
Benefits of being a part of the team	"I think it improved the relationship with my neuro colleagues."	"Great way to develop good relationship with consultants."
	"Things I learned: proper brain death exam, Stroke location based on symptoms, Acute stroke management."	"I think the neuro team sees me as 'more reliable' in a way because they trained me."
	"The NICU faculty provided lectures on ICH, blood pressure management, meningitis, and other ED relevant topics during the month I rotated there."	"I know people better now on their team, and it was great for enforcing a good relationship with them as consultants."
	"Our presence seemed to be very helpful as often the neurologists had little or no experience treating the non-neurologic pathology that their patients had."	"I now feel like the residents and attendings on stroke trust me to do this on a similar level as one of their residents."
Self-perceived improvement	"I feel I can do a better job when I consult (neurology colleagues) in the ED now"	"Improve(s) your ability read neuro imaging yourself."
	"It improved my skills doing a neurological examination in the critically ill, learnt the assessment of someone in a coma state, and how to monitor ICP."	(Re: CTA) "I never looked at them, and now I will look at them myself as much as I can."
		"I learned about ASPECTS scoring and CT perfusion."
Perceived benefit to residency education	"Truly an invaluable experience taught by expert leaders in the field."	"The cases I saw were valuable and interesting to follow up."
	"It was an excellent experience, and one that I recommend to other residents."	"It's a similar experience to rotating on CCU and seeing the outcomes of the AMI patients or trauma and seeing the outcomes of the badly injured trauma patients. Some cases had remarkable improvements, some minimal if any."

AIS = acute ischemic stroke; AMI = acute myocardial infarction; CCU = coronary care unit; CTA = computed tomography angiography; GBS = Guillain-Barre syndrome; ICH = intracerebral hemorrhage; ICP = intracranial pressure; MG = myasthenia gravis; NICU = neurologic intensive care unit; PRES = posterior reversible encephalopathy syndrome; SAH = subarachnoid hemorrhage; SDH = subdural hematoma.

stroke systems of care models have followed the evolution of trauma systems, with great success and stroke literature demonstrating improved outcomes.^{19,20}

Educationally, most training programs have not only continuous short-term exposure to trauma patients in an ED setting, but also a dedicated rotation (or

Table 4
Sample NICU Rotation Curriculum and Educational Objectives for EM Residents

Duration	2–4 weeks
Work hours	Mon–Fri 7 AM–5 PM Call range q4–q7 Cover two weekends per month Schedule will adhere to resident work week hours
Patient care expectations	Full responsibility for patients to include admissions, daily rounds, procedures, all medical management, discharges/transfers No cap for number of patients covered
Work activities objectives	Active presenter/participant in rounds, same responsibilities as neurology residents for patient with ICH, SAH, AIS, status epilepticus, and other neurologic emergencies Manage and direct ICH alerts and SAH alerts in the ED during the day and when on call with the NSICU Go to the intervention suite to observe thrombectomy cases for NSICU-destined patients, transfer patients from intervention suite to NSICU Go to select surgical cases in OR and first assist/observe NSICU procedures (EVD, trach, lines, etc.)
Educational activities objectives	Learn how to read a CT noncontrast brain for AIS, ICH, SAH, and other clinical entities/syndromes (i.e., herniation syndromes, mass effect, obstructive hydrocephalus, cerebral edema, anoxic injury after cardiac arrest) Learn how to identify a large-vessel occlusion on CTA head/neck Learn about management strategies and interventions for acute ischemic stroke, ICH, SAH, and other brain-injured patients in the NSICU Education regarding advanced neuroimaging and neuromonitoring (CT perfusion, ASPECTS scoring, MRI core assessment, continuous EEG) Demonstrate effective communication with families and patients incorporating patient preferences in clinical decisions, patient prognosis, and end-of-life care Learn about the brain-death examination and the clinical assessment of brain death Demonstrate the ability to make judicious use of consulting services and discussing the necessity for consultation with the attending physician Read key select publications about acute stroke care, management of status epilepticus, and other neurologic emergencies (these articles would be provided by the program) Meet with neurocritical faculty before and after the rotation to discuss objectives/expectations and review what was learned

AIS = acute ischemic stroke; CTA = computed tomography angiography; EEG = electroencephalogram; EVD = external ventricular drain; ICH = intracerebral hemorrhage; NICU = neurologic intensive care unit; NSICU = neurosurgical intensive care unit; OR = operating room; SAH = subarachnoid hemorrhage.

Table 5
Sample Stroke Rotation Curriculum and Educational Objectives for EM Residents

Duration	2–4 weeks
Work hours	Mon–Fri 7 AM–5 PM or 3 PM–12 AM Consider weekend coverage as well Schedule adheres to resident work week hours
Patient care expectations	Full responsibility for a certain number of patients to include admission, daily rounds, procedures, management, running stroke codes, and discharge planning No cap for number of patients covered
Work activities objectives	Active presenter/participant in rounds, same responsibilities as neurology residents for patients with AIS/TIA Manage and direct stroke alerts in the ED during the day and when on call with the stroke team Go to the intervention suite to observe thrombectomy cases, transfer patients from the intervention suite to the NICU
Educational activities objectives	Broaden neurologic examination skills Learn how to read a noncontrast CT brain and CTA head and neck Learn how to identify a large vessel occlusion Correlate neurologic examination findings to imaging Observe outcomes of patient after acute management Learn about management strategies and interventions for acute ischemic stroke and TIA Education regarding advanced neuroimaging (CT perfusion, ASPECTs scoring, MRI) Participate in reperfusion therapies for acute ischemic stroke in eligible patients and gain further understanding regarding clinical and radiographic eligibility criteria (thrombolysis, thrombectomy) Observe telemedicine cases with the stroke attending covering the telestroke program Become certified in other stroke assessment tools (modified Rankin score, ASPECTs score for MCA ischemia, MRI core assessment, MRI diffusion/FLAIR mismatch) Read key select publications about acute stroke care (these articles would be provided by the program) Meet with stroke director before and after the rotation to discuss objectives/expectations and review what was learned

AIS = acute ischemic stroke; CTA = computed tomography angiography; MCA = middle cerebral artery; NICU = neurologic intensive care unit; TIA = transient ischemic attack.

rotations) on a trauma service or in the surgical ICU. For neurologic disorders, our findings confirm the educational approach is extremely variable.

Previous articles regarding neurovascular education for EM residents had discussed their curriculum and evaluated knowledge. Interventions that appeared to be effective in educating residents included medical simulation, e-learning, lectures, and interdisciplinary conferences. Some of the outcomes obtained through these interventions are the ability to effectively recognize and manage acute strokes, prepare and administer for thrombolysis, calculate NIHSS, interpret CTs, and manage intracerebral hemorrhages. The preliminary work of our panel has identified continued variability over time for the institution of required neuroscience clinical rotations for EM residents. Specifically, in 2005 Stettler et al.⁴ surveyed 98 residency leaders demonstrating that only 34.7% require neurology or neurosurgery rotations (17.4% of programs had required rotations in neurology, while 15.2% had required rotations in neurosurgery). In our groups CORD query of 48 programs 52.1% of respondents indicated having a required rotation (6.2% general neurology, 2% stroke service, 18.8% NICU, 2% neurosurgery, 22.9% on a combination of services). Our results suggest higher utilization and greater diversity of rotations contrasted to the survey by Stettler et al. A total of 87.5% of our respondents indicated that their site was a comprehensive stroke center, thus perhaps revealing a selection bias that could overestimate results. Of further interest—only 31.3 and 50% of respondents indicated the availability of a dedicated stroke service and neurocritical care rotation, respectively, while 29.2% indicated residents rotate on either general neurology or a combination of services. The latter experience may dilute a trainee's cerebrovascular exposure. Thus, variability exists in the availability of these neurovascular/neurocritical care specific rotations, among respondents who predominantly worked at comprehensive stroke centers. In the future, a broader conversation between EM academic leaders and neurovascular and neurocritical care leaders may become necessary to identify optimal priorities and training venues.

From resident evaluations (Table 3) of stroke service and neurocritical care rotations acquired by panelists, performing dedicated clinical time appears to be beneficial with several themes becoming apparent. These clinical rotations serve to augment neurologic examination skills, provide exposure to a wide spectrum of

disease entities, allow residents to see the results of treatment interventions as they follow their patients, provide dedicated education for advanced imaging, and strengthen relationships between EM and the neurology teams. Additionally, while there have been great and important advancements in simulation-based education in EM, one respondent cited that the complexities of the neurologic examination cannot be replicated in a simulation.

A concentrated clinical experience, such as a dedicated rotation on a stroke service or in a NICU, can promote standardization of training. Although some components of what may be considered “core content”—including comprehensive and focused neurologic examinations, recognition of signs and symptoms of acute neurologic emergencies, appropriate triage of such emergencies, necessity of advanced imaging, and knowledge of basic emergent treatments for specific conditions—are incorporated into EM residency programs, training approaches of this information vary considerably. While some residents are involved in the care of acute neurologic emergencies as members, or even leaders, of a dedicated team, most others train in institutions with a strong neurology presence, where care is often immediately transitioned to the neurology team, sometimes on a patient's arrival in the ED and before any impactful clinical decisions have been made.

Such a concentrated clinical experience would ensure the accumulation of baseline knowledge, including both core content and newer evidenced-based management approaches, as well as strategies to optimize patient outcomes. As with similar off-service ED rotations, like trauma, in which the residents are often members of the trauma and surgical ICU teams, residents would be enmeshed as a member of the neurologic care team, either on the floors or in the NICU. There, they would not only become well versed in making critical emergent decisions for the care of neurologic patients but would also see the outcome of those decisions and resultant interventions. This follow-up would provide an important clinical context for the emergent care of the patient with the acute neurologic emergency, which is, unfortunately, often overlooked in current training programs. Furthermore, similarly to logging “trauma resuscitations,” residents could be encouraged to log “neurologic resuscitations” and “neurovascular follow-up” as a metric that could be used to evaluate both their clinical experience and readiness to practice independently of extensive support from neurologists.

Given recent advancements in the field, future consideration to augment EM residency training in this area merits strong consideration. Future collaboration between EM education experts and stroke and neurocritical care leaders is necessary to identify priorities and optimal mechanisms to incorporate neurovascular/neurocritical care into an EM residency curriculum with the overarching aim that all EM residents graduate with a basic fund of knowledge and skill set for the modern day management of stroke and cerebrovascular diseases.

LIMITATIONS

This manuscript has several limitations for different areas. Although the literature review followed standardized methods, it was a brief narrative review. We did not examine gray literature and did not assess the quality of the included studies. The initial number of articles was small, and it is possible that relevant articles were missed. For these reasons, the review is prone to publication bias. The program directors' survey is prone to selection bias and also is a relatively small sample size. However, it is the first survey of its kind since 2005 and achieved a sample size half the size of the prior survey. The resident evaluations of neurovascular elective rotations are prone to selection bias, reporting bias, and limited by a relatively small sample size. Other sections of our article are limited by the scope and opinions of this voluntary panel from the SNIG, but all members manifest an interest and expertise in neurologic emergencies with several having national oversight of advocacy organization committees and representation on national writing groups for clinical practice guidelines. Several are board certified or have performed cerebrovascular fellowship training, and several others have performed advanced research training. Several have also worked at their institutions for both EM and a neurologic/neurosurgical subspecialty service.

CONCLUSION

A neurocritical care or stroke service rotation can provide unique settings for emergency medicine residents to experience and learn a more focused, yet comprehensive approach to acute care neurovascular medicine. The incorporation of such a rotation into emergency medicine training programs should be strongly considered.

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Supporting Information

The following supporting information is available in the online version of this paper available at <http://onlinelibrary.wiley.com/doi/10.1002/aet2.10200/full>

Data Supplement S1. Supplemental material.