



Safety and Feasibility of a Rapid Outpatient Management Strategy for Transient Ischemic Attack and Minor Stroke: The Rapid Access Vascular Evaluation–Neurology (RAVEN) Approach

Bernard P. Chang, MD, PhD*; Sara Rostanski, MD; Joshua Willey, MD; Eliza C. Miller, MD; Steven Shapiro, MD; Rachel Mehendale, MD; Benjamin Kummer, MD; Babak B. Navi, MD, MS; Mitchell S. V. Elkind, MD, MS

*Corresponding Author. E-mail: bpc2103@cumc.columbia.edu, Twitter: [@bernardchangMD](https://twitter.com/bernardchangMD).

Study objective: Although most transient ischemic attack and minor stroke patients in US emergency departments (EDs) are admitted, experience in other countries suggests that timely outpatient evaluation of transient ischemic attack and minor stroke can be safe. We assess the feasibility and safety of a rapid outpatient stroke clinic for transient ischemic attack and minor stroke: Rapid Access Vascular Evaluation–Neurology (RAVEN).

Methods: Transient ischemic attack and minor stroke patients presenting to the ED with a National Institutes of Health Stroke Scale score of 5 or less and nondisabling deficit were assessed for potential discharge to RAVEN with a protocol incorporating social and medical criteria. Outpatient evaluation by a vascular neurologist, including vessel imaging, was performed within 24 hours at the RAVEN clinic. Participants were evaluated for compliance with clinic attendance and 90-day recurrent transient ischemic attack and minor stroke and hospitalization rates.

Results: Between December 2016 and June 2018, 162 transient ischemic attack and minor stroke patients were discharged to RAVEN. One hundred fifty-four patients (95.1%) appeared as scheduled and 101 (66%) had a final diagnosis of transient ischemic attack and minor stroke. Two patients (1.3%) required hospitalization (one for worsening symptoms and another for intracranial arterial stenosis caused by zoster) at RAVEN evaluation. Among the 101 patients with confirmed transient ischemic attack and minor stroke, 18 (19.1%) had returned to an ED or been admitted at 90 days. Five were noted to have had recurrent neurologic symptoms diagnosed as transient ischemic attack (4.9%), whereas one had a recurrent stroke (0.9%). No individuals with transient ischemic attack and minor stroke died, and none received thrombolytics or thrombectomy, during the interval period. These 90-day outcomes were similar to historical published data on transient ischemic attack and minor stroke.

Conclusion: Rapid outpatient management appears a feasible and safe strategy for transient ischemic attack and minor stroke patients evaluated in the ED, with recurrent stroke and transient ischemic attack rates comparable to historical published data. [Ann Emerg Med. 2019;74:562-571.]

Please see page 563 for the Editor's Capsule Summary of this article.

Readers: click on the link to go directly to a survey in which you can provide **feedback** to *Annals* on this particular article.

A **podcast** for this article is available at www.annemergmed.com.

0196-0644/\$-see front matter

Copyright © 2019 by the American College of Emergency Physicians.

<https://doi.org/10.1016/j.annemergmed.2019.05.025>

SEE EDITORIAL, P. 572.

INTRODUCTION

Background and Importance

Stroke is the third most common cause of death among women, the fifth most common cause of death among men, and the leading cause of serious long-term disability in the United States.¹ One of the major precursors of ischemic stroke is a transient ischemic attack, defined as a

transient episode of neurologic dysfunction caused by focal brain, spinal cord, or retinal ischemia, without acute infarction.² Transient ischemic attack is a common condition, with an estimated 250,000 to 300,000 events occurring annually in the United States.¹ It precedes stroke in approximately 15% to 26% of patients.³ The majority of strokes occur in the first week after transient ischemic attack, and the first 2 days after an attack are the highest-risk period, in which rates of stroke vary from 4% to 10%.⁴

Editor's Capsule Summary

What is already known on this topic

Many patients with transient ischemic attack are admitted because of the short-term risk of recurrent stroke.

What question this study addressed

Is rapid access to a specialized transient ischemic attack and minor stroke clinic a safe and feasible alternative to hospitalization after a brief initial emergency department (ED) evaluation?

What this study adds to our knowledge

None of the 162 patients experienced a disabling stroke within 90 days. No thrombectomies or thrombolytics were administered during follow-up. Approximately one third of the patients received alternative diagnoses in the clinic.

How this is relevant to clinical practice

This method for risk stratifying transient ischemic attack and minor stroke and starting aspirin is promising when close follow-up with vascular neurologists is achievable.

Research we would like to see

Prospective validation of this method is needed, ideally without an in-person neurology evaluation during the initial ED visit.

At 90 days, the rate of stroke after transient ischemic attack is approximately 9% to 10%.^{5,6} This early short-term risk emphasizes the critical importance of timely evaluation of transient ischemic attack, particularly because risk of stroke is determined largely by underlying cause.⁷ Although bedside scoring systems, such as the ABCD2 score, have been explored as potential risk-stratification tools, they are limited without the use of vascular imaging in identifying symptomatic large arterial stenosis.^{8,9} For example, symptomatic extracranial internal carotid artery stenosis is associated with a high short-term risk of recurrence and is not readily captured by current bedside decision tools or scoring systems.¹⁰

Rapid diagnostic evaluation of transient ischemic attack and minor stroke patients is recommended by the American College of Emergency Physicians (ACEP) and the American Heart Association/American Stroke Association (AHA/ASA) to initiate secondary stroke prevention and identify patients who may need rapid

carotid revascularization, yet practice variability exists about whether such timely follow-up can occur in the inpatient versus outpatient setting.^{2,11-13} Although most transient ischemic attack and minor stroke patients evaluated in US emergency departments (EDs) are admitted,¹⁴ experience in other countries suggests expedited outpatient evaluation can be both safe and cost-effective.¹⁵⁻¹⁷ In the United States, ED and neurology observation units have been developed in select hospitals for the expedited evaluation of transient ischemic attack and minor stroke.^{18,19} Outcomes data have been encouraging, with patients treated in observation units having shorter lengths of stay, lower total direct costs, comparable 90-day clinical outcomes, and a similar degree of adoption of secondary prevention medication strategies in comparison with patients admitted for transient ischemic attack and minor stroke.¹⁸⁻²⁴ Although the evidence in support of these observation units is promising, these units are not widely available, still involve the risk and cost of a hospital stay, and can contribute to hospital crowding. A safe and rapid outpatient discharge strategy may offer benefit in the management of transient ischemic attack and minor stroke patients beyond observation or short inpatient stay.

In accordance with evidence suggesting clinical equipoise for the disposition of transient ischemic attack and minor stroke patients, we undertook an interdisciplinary endeavor between the Departments of Emergency Medicine and Neurology at Columbia University Irving Medical Center to create a novel outpatient management strategy for the management of transient ischemic attack and minor stroke. This clinic, the Rapid Access Vascular Evaluation–Neurology (RAVEN) is, to our knowledge, among the first outpatient, integrated, rapid-access stroke clinics in the United States and may offer a safe alternative management strategy to inpatient admission of transient ischemic attack and minor stroke patients.

Goals of This Investigation

The goal of this research report is to describe the feasibility and safety of an outpatient treatment strategy for the management of transient ischemic attack and minor stroke. Specifically, we aimed to report RAVEN feasibility and safety, diagnoses and care at initial evaluation, and outcomes at 90-day follow-up for transient ischemic attack and minor stroke patients treated in RAVEN.

MATERIALS AND METHODS

Study Design and Setting

This study was a retrospective review of records and outcomes among individuals referred to a rapid outpatient

transient ischemic attack and minor stroke clinic in a quaternary academic medical center in an urban setting and a designated comprehensive stroke center. The study protocol was reviewed and approved by the Columbia University Irving Medical Center institutional review board; waiver of informed consent was granted because this was a retrospective review of existing records.

In designing the protocol for RAVEN, we sought to identify transient ischemic attack and minor stroke patients for whom ED discharge to RAVEN follow-up within 24 hours would pose minimal adverse short-term neurologic risk while considering potential limitations in functional or social factors that would permit rapid outpatient evaluation. The RAVEN protocol and criteria are summarized in the [Figure](#).

Creation of the RAVEN clinic occurred in 3 phases, spanning approximately 12 months from conception to implementation. First, a team of 1 emergency physician and 4 vascular neurologists completed and published a clinical review of extant literature summarizing the use of existing risk-stratification methods for transient ischemic attack and minor stroke in the ED setting, evidence for near-term risk of adverse neurologic events in transient ischemic attack and minor stroke, and extant disposition strategies for the management of transient ischemic attack and minor stroke in the emergency setting.¹³ Based on

this clinical review, a preliminary set of criteria and protocol were created. Second, building on the initial criteria, in-person meetings were held with the Departments of Emergency Medicine and Neurology to obtain feedback and feasibility from the practicing clinicians in both departments to address acute neurologic and medical issues, as well as potential social factors and follow-up concerns. Finally, the draft protocol was reviewed by departmental and senior hospital leadership for approval and administrative support.

Selection of Participants

From December 2016 through June 2018, patients treated in the ED who had a possible nondisabling transient ischemic attack and minor stroke were screened for potential RAVEN discharge by the consulting neurology resident in the ED. It is the policy at our institution that all patients with a possible transient ischemic attack and minor stroke in the ED undergo brain imaging with computed tomography (CT) and have an ED consultation by a neurology resident at the request of the attending emergency physician. All such cases are then discussed with a board-certified vascular neurologist before ED disposition. As summarized in the [Figure](#), disabling symptoms were defined in accordance with AHA/ASA acute guidelines on the management of acute stroke, based

Screen TIAM NIHSS 5 or less with no Disabling Deficit

(Disabling deficit defined as)

- Complete hemianopsia
- Severe Aphasia
- Visual or sensory extinction
- New weakness limiting sustained effort against gravity
- New gait impairment
- Symptoms that warrant inpatient physical or occupational therapy
- Dysphagia that warrant formal evaluation

None of the Following

- Head CT positive for intracerebral hemorrhage
- Patient treated with IV tPA for acute stroke
- Fluctuating or recurrent symptoms within the past month
- EKG shows new onset atrial fibrillation or new MI
- Carotid imaging within last 6 months shows >50% carotid stenosis on symptomatic side
- Blood pressure persistently elevated over 180/110 mm Hg or IV anti hypertensive agents administered
- Ability to follow-up within 24 hours

Discharge to RAVEN

- Outpatient follow-up schedule to RAVEN within 24 hours in ED prior to discharge
- Given ASA 81mg prior to discharge
- Hemoglobin A1C and lipid panel added to labs

Figure. RAVEN protocol. *TIAMS*, Transient ischemic attack and minor stroke; *MI*, myocardial infarction; *NIHSS*, National Institutes of Health Stroke Scale.

on the following: complete hemianopia, severe aphasia, dysphagia, gait disorder, visual or sensory extinction, new weakness limiting sustained effort against gravity, symptoms warranting physical or occupational therapy assessment, or a National Institutes of Health Stroke Scale (NIHSS) score greater than 5.²⁵ Our criteria for RAVEN eligibility built on this and also included a list of additional criteria for RAVEN discharge, including head CT imaging with no evidence of hemorrhage, no treatment with thrombolysis in the ED, no fluctuating symptoms or recurrent symptoms within the past month, ECG showing no new-onset atrial fibrillation or cardiac ischemia, no evidence of blood pressure persistently greater than 180/110 mm Hg, no intravenous hypertensive agents administered in the ED, no known large artery stenosis of greater than 50%, and ability to follow up within 24 hours. For the initial implementation of RAVEN, because of available hospital and staffing resources, the RAVEN clinic operated on weekdays from Monday to Friday, with no clinic on weekends or holidays. In accordance with AHA/ASA guidelines, patients with nondisabling minor strokes are generally not considered eligible for mechanical thrombectomy.²⁵

If the patient met all criteria for referral to RAVEN, the protocol required that all appointments for follow-up be made during the ED visit by the stroke team on the patient's behalf, and patients were given specific instructions in their primary language, including a map showing the location and time of the RAVEN appointment. Contact information was collected for each patient, and an e-mail was generated by the stroke team for each patient discharged for RAVEN follow-up and sent to a RAVEN clinic scheduler or administrator, as well as the RAVEN clinicians. Patients were given contact information for the clinic for any changes or concerns, and they were explicitly told to return to the ED for evaluation for any change or worsening of symptoms.

At the RAVEN clinic visit within 24 hours, patients were evaluated by a board-certified vascular neurologist, and outpatient vascular imaging with carotid duplex and transcranial Doppler were conducted that same day, in keeping with recommendations for evaluation of transient ischemic attack and minor stroke (AHA/ASA and Canadian best practices).^{25,26} Patients were also referred for magnetic resonance imaging, echocardiogram, and outpatient Holter monitoring at the discretion of the vascular neurologist. Blood pressure, antithrombotic, and statin medications were optimized as clinically indicated. Counseling on lifestyle modifications, including smoking cessation and risk-factor control, was also provided. Referrals to the

RAVEN clinic occurred regardless of insurance status, and if uninsured or underinsured, patients were not charged for the visit. Any patients who were deemed to require internal carotid artery intervention or had a change in neurologic or medical status were admitted directly to the hospital from the RAVEN clinic.

Methods of Measurement and Outcome Measures

Baseline demographics, including age, sex, primary language, and insurance status, were collected for all participants. Medical information collected included baseline vital signs (eg, blood pressure), NIHSS score at initial ED presentation, and modified Rankin Scale score for pre-transient ischemic attack and minor stroke disability.²⁷ Rates of participant follow-up to the RAVEN clinic were tabulated, together with any adverse events, including recurrent stroke, death, or revisit to the hospital during the 24-hour period before the RAVEN clinic visit. Frequency of required admission after reevaluation at the RAVEN clinic was tabulated, along with reason for admission. Final diagnosis of the patient was determined by the treating vascular neurologist in the RAVEN clinic after review of all clinical variables and imaging. The final diagnosis was categorized as either possible or definite ischemic stroke, transient ischemic attack, or a transient ischemic attack and minor stroke mimic (migraine, peripheral neuropathy, vestibular, and others).

All patients were contacted by telephone at 90 days as part of our comprehensive stroke center operations to assess whether there were any new neurologic or cardiovascular events, as well as all-cause rehospitalization (including ED visits). If the patient could not be contacted, the primary care provider, family member or next of kin, or both were contacted. In addition, interval chart review was performed. Patients lost to follow-up (eg, those who did not keep their appointment) at the 24-hour RAVEN clinic were categorized by reason for not keeping the appointment, and telephone and primary care provider contact was reattempted (if contact information was provided).

RESULTS

Characteristics of Study Subjects

From December 2016 until June 2018, 253 patients were screened for possible RAVEN discharge, with 162 individuals with transient ischemic attack and minor stroke in the ED enrolled for discharge to the RAVEN clinic. Among the 91 individuals who were screened but did not meet RAVEN discharge criteria, 58 were evaluated when RAVEN follow-up within 24 hours was not possible (eg, weekend or holiday), whereas 33 were found to have either

Table 1. Participant demographics.

RAVEN Participant Demographics	n = 162
Mean age (SD), y	63.3 (15.6)
Age range, y	25.1–97.4
Female sex, No. (%)	96 (59.3)
Mean Rankin Scale score (SD)	0.6 (SD 1.1)
Median Rankin Scale score (IQR)	0 (0–1)
Mean NIHSS score (SD)	0.98 (1.59)
Median NIHSS score (IQR)	0 (0–2)
Mean initial systolic blood pressure (SD), mm Hg	151 (25)
Mean initial diastolic blood pressure, mm Hg	86 (15.6)
Primary language, No. (%)	
English	91 (56.2)
Spanish	61 (37.7)
Bilingual	3 (1.9)
Other	7 (4.3)
Insurance status	
Medicare	61 (37.7)
Medicaid	43 (26.5)
Commercial insurance	46 (28.4)
Other	8 (4.9)
Uninsured/self-pay	4 (2.5)

IQR, Interquartile range.

a disabling deficit or a social reason for being unable to follow up within 24 hours. Baseline demographics for the 162 RAVEN patients are summarized in [Table 1](#).

Patient characteristics at RAVEN follow-up are summarized in [Table 2](#). Of the 162 individuals scheduled and discharged to RAVEN from the ED, 154 (95.1%) followed up in the RAVEN clinic the next day. There were no patients who developed a subsequent deficit within 24 hours of the initial visit in the ED who would have been

Table 2. RAVEN follow-up characteristics.

RAVEN Patient Characteristics	Frequency (%)
Followed up in RAVEN within 24 h	154 of 162 (95.1)
Final diagnosis	
TIA	42 (28)
Minor stroke	59 (38)
Unknown	3 (2)
Other (eg, seizure, recrudescence)	7 (4)
Peripheral neuropathy	23 (15)
Migraine	20 (13)

TIA, Transient ischemic attack.

eligible for thrombolytics or thrombectomy. Among the 8 individuals who did not present to the RAVEN clinic at 24 hours, 2 returned within 48 hours as a result of scheduling conflicts and confusion about timing of follow-up; 2 were ultimately not discharged from the ED and were admitted to a medicine service; and another patient, with a known history of metastatic cancer, left against medical advice. Finally, 3 patients were lost to follow-up, with no further information, leaving 3 (1.8%) of our sample with unexplained lack of clinic attendance.

In our sample of 162 RAVEN patients, before disposition to the RAVEN clinic, 7 (4.3%) were already maximally medically managed (receiving dual antiplatelet therapy and statin), whereas 56 were already receiving a single antiplatelet such as aspirin or clopidogrel (38.2%). In the ED, before being discharged to the RAVEN clinic, 22 patients (13.5%) had a computed tomography angiography head or neck scan and 2 patients (1.2%) had an magnetic resonance imaging or magnetic resonance angiography before discharge. In terms of neurologic disability, mean NIHSS score for patients at ED discharge to the RAVEN clinic was 0.98 (SD 1.59), with a median NIHSS score of 0 (interquartile range 0 to 2). Mean baseline modified Rankin Scale score at ED discharge to the RAVEN clinic was 0.6 (SD 1.1), with a median of 0 (interquartile range 0 to 1). Of the 154 individuals who followed up in the RAVEN clinic, 101 (66%) were found to have a final diagnosis of transient ischemic attack (42) or minor stroke (59). The agreement (κ) for discharge diagnosis and final diagnosis was 0.27 for the 154 participants who followed up in the RAVEN clinic. The remaining patients received a diagnosis of a stroke mimic, including 23 (15%) with peripheral neuropathy, 20 (13%) with migraine, and 7 (4%) with other conditions such as seizure or recrudescence (transient worsening) of previous stroke symptoms in the setting of medical illness or medication; 3 patients (2%) did not have an established final diagnosis. Five patients (3.2%) had MRI studies conducted at the RAVEN clinic. One individual was found to have a positive finding on diffusion weighted imaging indicative of stroke (right internal

Table 3. Ninety-day outcomes for RAVEN patients.

90-Day Outcomes Assessed for the 162 RAVEN Patients	No. (%)
Readmitted or returned to ED	28 (19.7)
Recurrent TIA	6 (3.7)
Recurrent stroke	1 (0.7)
Death from any cause	2 (1.4)
Lost to follow-up at 90 days	17 (10.5)

capsular) and was subsequently admitted from the RAVEN clinic. Out of the patients treated in the RAVEN clinic, 2 (1.3%) required hospitalization (one for the aforementioned capsular stroke and another for diffuse intracranial arterial stenosis caused by zoster vasculitis) and were directly admitted to the neurology service from the clinic.

The 90-day outcomes are summarized in Table 3. Among the 162 patients discharged to the RAVEN clinic, 17 were lost to follow-up at 90 days (10.5%), leaving 145 who successfully completed follow-up. Of these 145 patients, during the 90-day period, 28 (19.3%) presented again to an ED or were admitted to the hospital; 6 (3.7%) were noted to have recurrent transient ischemic attack symptoms; 1 (0.7%) had a recurrent stroke. Two individuals (1.4%) died, one of metastatic cancer and the other of respiratory failure and congestive heart failure. Of the remaining 19 readmissions, 9 were for cardiac reasons (syncope, heart failure exacerbation, hypertension, and elective valve repair); 7 for potential neurologic complaints (lip tingling, dizziness, and vertigo), of whom all were evaluated and discharged from the ED without need for inpatient admission; and 3 for miscellaneous (chemotherapy, urologic complaint, and alcohol intoxication). None of the readmissions were judged to be preventable according to missed secondary prevention treatment, or related to the index transient ischemic attack and minor stroke. In our sample, no patients at follow-up were found to have undergone thrombectomy or received thrombolysis (eg, tissue plasminogen activator).

Ninety-day outcome data for the 154 patients who followed up in the RAVEN clinic stratified by their final discharge diagnosis are presented in Table 4. Patients with a

final RAVEN diagnosis of transient ischemic attack and minor stroke (n=101) were compared with those with a final RAVEN diagnosis of a stroke mimic (n=53). Among transient ischemic attack and minor stroke patients, by 90 days, there were no reported deaths. Six individuals in the sample had a new transient ischemic attack or minor stroke (5.9%).

LIMITATIONS

Our study was a single-site cohort study at an academic urban medical center with a comprehensive stroke center designation, with in-house consulting neurology, limiting the generalizability of our findings to sites with different existing neurology infrastructure and different patient populations served. Additionally, although follow-up was conducted both through chart review and 90-day telephone calls, we were unable to establish contact with 10.5% of our sample, making it possible that some potential adverse events were not accounted for in our analysis. However, although the overall rate of being lost to follow-up was 10.5%, that for patients with a final diagnosis of transient ischemic attack and minor stroke was 8.9% compared with that for mimics (13.2%). The lower rate of follow-up among the true transient ischemic attack and minor stroke patients compared with those with transient ischemic attack and minor stroke mimics is reassuring from an acute recurrent stroke outcome perspective. Additionally, the 90-day rate of being lost to follow-up may in part reflect our study design. Because this was a pilot study using a retrospective chart review design and not a prospective cohort study with planned 90-day follow-up, we did not have any existing infrastructure or mechanisms to optimize follow-up beyond the 24-hour RAVEN clinic assessment. Future prospective trials assessing the near-term and 90-day outcomes in similar transient ischemic attack and minor stroke samples will ideally be better poised to improve near- and long-term follow-up.

Finally, because the primary aim of this study was to assess feasibility and safety of the RAVEN clinic, it did not have a comparator group.

DISCUSSION

We implemented a novel rapid outpatient-management approach, the RAVEN clinic, for transient ischemic attack and minor stroke patients evaluated in the ED. Although such outpatient strategies have been described in other countries,^{16,28} this study represents among the first published efforts of such rapid outpatient strategies for transient ischemic attack and minor stroke

Table 4. Ninety-day outcomes stratified by final RAVEN diagnosis.

	No. (%)
90-day outcomes assessed for the 101 RAVEN patients with a final diagnosis of TIAMS	
Readmitted or returned to ED	18 (19.1)
New TIA or stroke	6 (5.9)
Death from any cause	0
Lost to follow-up at 90 days	9 (8.9)
90-day outcomes assessed for the 53 RAVEN patients with a final diagnosis of a stroke mimic	
Readmitted or returned to ED	10 (20.4)
New TIA or stroke	1 (1.9)
Death from any cause	2 (3.7)
Lost to follow-up at 90 days	7 (13.2)

in the United States. Our preliminary data suggest that such a protocol is a safe and feasible strategy for select transient ischemic attack and minor stroke patients. Because the goal of this study was focused on assessing the safety and feasibility of such a rapid outpatient neurology strategy, we did not have an a priori comparison group of inpatient strategies or ED observation strategies. However, our initial and 90-day safety outcomes were similar to those of several large published trials involving transient ischemic attack and stroke patients. In a prospective clinical trial of 4,557 transient ischemic attack and minor stroke patients (Platelet Oriented Inhibition in New TIA and Minor Ischemic Stroke), rates of stroke recurrence (6.3%) and 90-day death from any cause (0.5%) in the control arm were similar to or higher in percentage than such outcomes in the RAVEN clinic.²⁹ Our 90-day stroke rates were also similar to those observed in the Transient Ischemic Attack Clinic With Round-the-clock Access¹⁵ and the Effect of Urgent Treatment of Transient Ischemic Attack and Minor Stroke on Early Recurrent Stroke studies, in which 90-day rates of stroke among confirmed transient ischemic attack and minor stroke patients ranged from 1.7% to 2.1%¹⁶ and provide further support that urgent outpatient evaluation and vascular imaging may be a feasible approach to the management of transient ischemic attack and minor stroke.^{15,16} Administering thrombolytics rapidly if a recurrent disabling deficit is identified is a commonly cited reason for hospitalizing transient ischemic attack patients, but we did not observe any patients for whom this would have been the case.³⁰

Transient ischemic attack and minor stroke patients are commonly evaluated in the ED; however, wide practice variability exists in regard to the ED management and disposition of these patients. The proportion of transient ischemic attack and minor stroke patients admitted in the United States is substantial,^{14,31} contributing to ballooning health care costs of caring for them. Previous work has suggested that hospitalizing transient ischemic attack patients may not be cost-effective.³² ED observation units and short-term-stay inpatient units are other possible sites for transient ischemic attack and minor stroke evaluation, but median lengths of stay in these units remain approximately 24 hours and costs may be high.^{19,33} The adoption of a rapid outpatient evaluation of transient ischemic attack and minor stroke patients has the potential to reduce unnecessary hospital admissions and reduce overall length of stay for transient ischemic attack and minor stroke patients, with downstream implications for ED and inpatient bed-flow

management. In addition to these potential positive operational and cost savings, an outpatient strategy may have salutary effects on factors such as patient preferences and decreased nosocomial risk associated with hospital admission. Emerging work from behavioral sciences has shown that hospitalization may be associated with the development of adverse psychological outcomes, including the development of posttraumatic stress disorder.^{34,35} Outpatient transient ischemic attack and minor stroke management strategies such as a RAVEN clinic may have the additional benefit of reducing risk of psychological distress.

Future work building on these initial data from the RAVEN clinic may offer additional insight and applications for emergency clinicians in regard to disposition and management of transient ischemic attack and minor stroke.

The role of rapid outpatient approaches should be assessed in a variety of clinical settings to evaluate whether such strategies are feasible and safe across multiple practice environments, including the construction of clinical trials and matched comparison groups to evaluate whether such outpatient strategies provide similar neurologic or different health outcomes in transient ischemic attack and minor stroke patients compared with inpatient or observation strategies. Additionally, data garnered from these studies could guide the refinement of existing and future outpatient transient ischemic attack and minor stroke protocols. Outstanding issues, such as whether vessel imaging (eg, CT, magnetic resonance angiography) should be conducted in the ED before discharge or at 24-hour follow-up in a rapid outpatient approach could be assessed in future studies. In our study, only a small proportion of patients received vessel imaging in the ED before discharge to the RAVEN clinic, demonstrating that ours appears a safe approach. In addition, an outpatient transient ischemic attack and minor stroke evaluation strategy is well poised to adapt to practice changes in acute medical therapy of transient ischemic attack and minor stroke patients. Specifically, 2 recent large clinical trials have demonstrated the benefit of acute dual antiplatelet therapy on reducing early stroke risk in transient ischemic attack and minor stroke patients.^{36,37} This is an intervention that can be easily incorporated into an outpatient transient ischemic attack and minor stroke management strategy because dual antiplatelet therapy can be initiated in the ED and then continued on an outpatient basis, pending RAVEN evaluation and confirmation of transient ischemic attack and minor stroke diagnosis.

The use of such outpatient strategies for transient ischemic attack and minor stroke may also offer potential

cost savings for health care systems and avoid costly and unnecessary hospital admissions. Although the aim of this study was the safety and feasibility of RAVEN rather than cost-effectiveness, recent data presented by our group showed that RAVEN patients had decreased direct hospital costs compared with transient ischemic attack and minor stroke patients managed in an inpatient setting.³⁸ Future work evaluating the implications of a RAVEN approach, to hospital factors such as total direct cost, revenue, and bed capacity may highlight the broader health economic effect that such an outpatient strategy may have for health systems.

An initial concern about RAVEN implementation was that the wide variability in clinical transient ischemic attack diagnosis could potentially lead to outpatient evaluation of many nonvascular or stroke patients, leading to an overburden of the rapid access clinic system. However, this did not prove to be true. On average, RAVEN treated approximately 3 patients a week, and we found a 66% concordance rate between ED diagnosis of transient ischemic attack and minor stroke and final discharge diagnosis by vascular neurologists. This rate was similar to those of previous ED and general practitioner-based studies^{19,39,40} and notably better than that of an admitted transient ischemic attack cohort.⁴¹ The subjectivity in the diagnosis of transient ischemic attack highlights another important role for rapid outpatient transient ischemic attack and minor stroke evaluation: reassessment by another clinician (eg, in this case a board-certified vascular neurologist). There is well-described variability in transient ischemic attack diagnostic accuracy across a range of practitioners,⁴² and being able to assess a patient multiple times in the acute setting by different providers may help with diagnostic accuracy and prevent unnecessary testing and interventions in patients found to have mimics. The rapid access to vascular neurologists in the RAVEN clinic limited the evaluation in the 34% of patients who were found to have an alternative nontransient ischemic attack and minor stroke diagnosis. Additional work building on the data from this study may assess the diagnostic accuracy of transient ischemic attack and minor stroke across a range of clinical settings and providers.

Finally, with the emergence of novel platforms for patient care, such as telemedicine, future studies might assess whether such programs may permit remote evaluations and referrals to rapid outpatient stroke clinics by neurology consultants in practice settings in which onsite neurology consultation may not be readily available. An integration of these innovative platforms with a rapid outpatient stroke strategy may result in a

synergistic comprehensive treatment program for transient ischemic attack and minor stroke, avoiding potential inpatient admissions and allowing greater access to specialized neurologic care in diverse clinical settings.

Transient ischemic attack and minor stroke are common conditions evaluated in the ED and are associated with significant morbidity and mortality. Our study has demonstrated that a rapid outpatient follow-up strategy for the management of transient ischemic attack and minor stroke may be a safe and feasible strategy in the acute care setting. Such an outpatient transient ischemic attack and minor stroke management strategy has the potential to improve ED throughput, reduce inpatient hospitalizations, and lead to reductions in secondary hospital-associated adverse outcomes and health care-associated costs of such acute illnesses.

Supervising editor: William J. Meurer, MD, MS. Specific detailed information about possible conflict of interest for individual editors is available at <https://www.annemergmed.com/editors>.

Author affiliations: From the Department of Emergency Medicine (Chang) and Department of Neurology (Willey, Miller, Shapiro, Mehendale, Kummer, Elkind), Columbia University Irving Medical Center, New York, NY; the Department of Neurology, New York University Medical Center, New York, NY (Rostanski); the Department of Neurology, Weill Cornell Medicine, New York, NY (Navi); and the Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY (Elkind).

Author contributions: BPC, SR, JW, BBN, and MSVE conceived the study, designed the trial, and obtained research funding. BPC, SR, ECM, SS, RM, and BK supervised the conduct of the trial and data collection. BPC, SR, JW, ECM, SS, BK, and BBN undertook recruitment of participating centers and patients and managed the data, including quality control. BPC, JW, ECM, and MSVE provided statistical advice on study design and analyzed the data. BPC and SR drafted the article, and all authors contributed substantially to its revision. BPC takes responsibility for the paper as a whole.

All authors attest to meeting the four [ICMJE.org](http://www.icmje.org) authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist. This work was supported by the National Institutes of Health (grant R01 HL141811) and the Empire Clinical Research Investigator Program (New York).

Publication dates: Received for publication February 13, 2019. Revision received April 23, 2019. Accepted for publication May 10, 2019.

Presented at the national meeting of the American College of Emergency Physicians, October 2018, San Diego, CA; and the International Stroke Conference, February 2019, Honolulu, HI.

REFERENCES

- Mozaffarian D, Benjamin EJ, Go AS, et al. Executive summary: Heart Disease and Stroke Statistics—2016 update: a report from the American Heart Association. *Circulation*. 2016;133:447-454.
- Easton JD, Saver JL, Albers GW, et al. Definition and evaluation of transient ischemic attack: a scientific statement for healthcare professionals from the American Heart Association/American Stroke Association Stroke Council; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular Nursing; and the Interdisciplinary Council on Peripheral Vascular Disease. *Stroke*. 2009;40:2276-2293.
- Rothwell PM, Warlow CP. Timing of TIAs preceding stroke: time window for prevention is very short. *Neurology*. 2005;64:817-820.
- Wu CM, McLaughlin K, Lorenzetti DL, et al. Early risk of stroke after transient ischemic attack: a systematic review and meta-analysis. *Arch Intern Med*. 2007;167:2417-2422.
- Hill MD, Yiannakoulis N, Jeerakathil T, et al. The high risk of stroke immediately after transient ischemic attack: a population-based study. *Neurology*. 2004;62:2015-2020.
- Johnston SC, Rothwell PM, Nguyen-Huynh MN, et al. Validation and refinement of scores to predict very early stroke risk after transient ischaemic attack. *Lancet*. 2007;369:283-292.
- Amarenco P, Lavallee PC, Labreuche J, et al. One-year risk of stroke after transient ischemic attack or minor stroke. *N Engl J Med*. 2016;374:1533-1542.
- Wardlaw JM, Brazzelli M, Chappell FM, et al. ABCD2 score and secondary stroke prevention: meta-analysis and effect per 1,000 patients triaged. *Neurology*. 2015;85:373-380.
- Perry JJ, Sharma M, Sivilotti ML, et al. Prospective validation of the ABCD2 score for patients in the emergency department with transient ischemic attack. 2011;183:1137-1145.
- Yaghi S, Rostanski SK, Boehme AK, et al. Imaging parameters and recurrent cerebrovascular events in patients with minor stroke or transient ischemic attack. 2016;73:572-578.
- Lo BM, Carpenter CR, Hatten BW, et al. Clinical policy: critical issues in the evaluation of adult patients with suspected transient ischemic attack in the emergency department. *Ann Emerg Med*. 2016;68:354-370.e329.
- Johnston SC, Albers GW, Gorelick PB, et al. National Stroke Association recommendations for systems of care for transient ischemic attack. *Ann Neurol*. 2011;69:872-877.
- Chang BP, Rostanski S, Willey J, et al. Can I send this patient with stroke home? Strategies managing transient ischemic attack and minor stroke in the emergency department. *J Emerg Med*. 2018;54:636.
- Chaudhry SA, Tariq N, Majidi S, et al. Rates and factors associated with admission in patients presenting to the ED with TIA in the United States—2006 to 2008. *Am J Emerg Med*. 2013;31:516-519.
- Lavallee PC, Meseguer E, Abboud H, et al. A transient ischaemic attack clinic with round-the-clock access (SOS-TIA): feasibility and effects. *Lancet Neurol*. 2007;6:953-960.
- Rothwell PM, Giles MF, Chandratheva A, et al. Effect of urgent treatment of transient ischaemic attack and minor stroke on early recurrent stroke (EXPRESS study): a prospective population-based sequential comparison. *Lancet*. 2007;370:1432-1442.
- Sanders LM, Cadilhac DA, Srikanth VK, et al. Is nonadmission-based care for TIA patients cost-effective? a microcosting study. *Neurol Clin Pract*. 2015;5:58-66.
- Stead LG, Belloio MF, Suravaram S, et al. Evaluation of transient ischemic attack in an emergency department observation unit. *Neurocrit Care*. 2009;10:204.
- Nahab F, Leach G, Kingston C, et al. Impact of an emergency department observation unit transient ischemic attack protocol on length of stay and cost. *J Stroke Cerebrovasc Dis*. 2012;21:673-678.
- Roberts RR, Zalenski RJ, Mensah EK, et al. Costs of an emergency department-based accelerated diagnostic protocol vs hospitalization in patients with chest pain: a randomized controlled trial. *JAMA*. 1997;278:1670-1676.
- Gomez MA, Anderson JL, Karagounis LA, et al. An emergency department-based protocol for rapidly ruling out myocardial ischemia reduces hospital time and expense: results of a randomized study (ROMIO). *J Am Coll Cardiol*. 1996;28:25-33.
- Rydman RJ, Zalenski RJ, Roberts RR, et al. Patient satisfaction with an emergency department chest pain observation unit. *Ann Emerg Med*. 1997;29:109-115.
- Ross MA, Compton S, Medado P, et al. An emergency department diagnostic protocol for patients with transient ischemic attack: a randomized controlled trial. *Ann Emerg Med*. 2007;50:109-119.
- Giles MF, Rothwell PM. Risk of stroke early after transient ischaemic attack: a systematic review and meta-analysis. *Lancet Neurol*. 2007;6:1063-1072.
- Powers WJ, Rabinstein AA, Ackerson T, et al. 2018 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*. 2018;49:e46-e110.
- Wein T, Lindsay MP, Côté R, et al. Canadian stroke best practice recommendations: secondary prevention of stroke, practice guidelines, update 2017. *Int J Stroke*. 2018;13:420-443.
- Fish J, Rankin Scale. In: Kreutzer J, DeLuca J, Caplan B, eds. *Encyclopedia of Clinical Neuropsychology*. Richmond, VA: Springer; 2011:2110-2112.
- Lavallée P, Amarenco P. TIA clinic: a major advance in management of transient ischemic attacks. In: Uchiyama S, Amarenco P, Minematsu K, Wong KSL, eds. *TIA as Acute Cerebrovascular Syndrome*. Vol 33. Tokyo, Japan: Karger Publishers; 2013:30-40.
- Johnston SC, Easton JD, Farrant M, et al. Platelet-Oriented Inhibition in New TIA and Minor Ischemic Stroke (POINT) trial: rationale and design. *Int J Stroke*. 2013;8:479-483.
- Nguyen-Huynh MN, Johnston SC. Is hospitalization after TIA cost-effective on the basis of treatment with tPA? *Neurology*. 2005;65:1799-1801.
- Durrani-Tariq S, Eskin B, Allegra JR. Admission rates of ED patients with transient ischemic attack have increased since 2000. *Am J Emerg Med*. 2013;31:1349-1351.
- Joshi JK, Ouyang B, Prabhakaran S. Should TIA patients be hospitalized or referred to a same-day clinic? a decision analysis. *Neurology*. 2011;77:2082-2088.
- Ross MA, Compton S, Medado P, et al. An emergency department diagnostic protocol for patients with transient ischemic attack: a randomized controlled trial. *Ann Emerg Med*. 2007;50:109-119.
- Edmondson D, Green P, Ye S, et al. Psychological stress and 30-day all-cause hospital readmission in acute coronary syndrome patients: an observational cohort study. *PLoS One*. 2014;9:e91477.
- White M, Edmondson D, Umland R. Patient perceptions of stress during evaluation for ACS in the ED. *Am J Emerg Med*. 2017;35:351.
- Johnston SC, Easton JD, Farrant M, et al. Clopidogrel and aspirin in acute ischemic stroke and high-risk TIA. *N Engl J Med*. 2018;379:215-225.

37. Wang Y, Wang Y, Zhao X, et al. Clopidogrel with aspirin in acute minor stroke or transient ischemic attack. *N Engl J Med*. 2013;369:11-19.
38. Shapiro SD, Luna J, Mehendale R, et al. Abstract TP277: a hospital's perspective: economic evaluation of hospitalization vs rapid outpatient evaluation for TIA and minor strokes. *Stroke*. 2019;92:3-10.
39. Schrock JW, Glasenapp M, Victor A, et al. Variables associated with discordance between emergency physician and neurologist diagnoses of transient ischemic attacks in the emergency department. *Ann Emerg Med*. 2012;59:19-26.
40. Gibbs RG, Newson R, Lawrenson R, et al. Diagnosis and initial management of stroke and transient ischemic attack across UK health regions from 1992 to 1996: experience of a national primary care database. *Stroke*. 2001;32:1085-1090.
41. Prabhakaran S, Silver AJ, Warrior L, et al. Misdiagnosis of transient ischemic attacks in the emergency room. *Cerebrovasc Dis*. 2008;26:630-635.
42. Ferro JM, Falcao I, Rodrigues G, et al. Diagnosis of transient ischemic attack by the nonneurologist. A validation study. *Stroke*. 1996;27:2225-2229.

Clinical Resources in *Annals* Systematic Review Snapshots

The Systematic Review Snapshot (SRS) articles select and summarize systematic reviews from the current literature to highlight for readers of *Annals*. Over 200 SRS articles are available on 18 categories of the EM model. Find the best evidence in a quickly digestible format today; go to the Collections pull down menu and click on EBEM Systematic Review Snapshots on the *Annals* Web site (www.annemergmed.com).

The screenshot shows the homepage of the Annals of Emergency Medicine website. The header includes the journal title, navigation links (Articles & Issues, Collections, Images, For Authors, Journal Info, Journal Access, Subscribe, Resources, ACEP), and social media icons. A search bar is located below the header. The main content area features a 'Featured This Month' section with a large 'NEW PERSPECTIVE' graphic. A 'Collections' dropdown menu is open, listing various categories, with 'EBEM Systematic Review Snapshots' highlighted in blue. Other categories include Editors Free Top Selections, Annals CME Articles, News and Perspective, Podcasts, Journal Club, FOAM, Expert Clinical Management, Residents' Perspective, Review Articles, Safety/Operations, EBEM Resources, Disaster Medicine, Change of Shift, Case Reports, Peer Review Science, ACEP Clinical Policies, and ABEM LLSA Reading. The right sidebar contains sections for 'Current Issue' (March 2017, Volume 69, Issue 3), 'Past Issues', 'New Content Alerts', and 'Podcasts' with a player interface.