Clinical Characteristics and Emergent Therapeutic Interventions in Patients Evaluated through the In-hospital Stroke Alert Protocol

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Background and Purpose: Emergent evaluation of inpatients with suspected acute ischemic stroke faces difficulty of symptoms recognition, false alarms, and high rate of contraindications to reperfusion therapies. We aim to assess the clinical characteristics and therapeutic interventions implemented in patients evaluated though the in-hospital Stroke Alert Protocol. *Methods:* We analyzed 4 years-worth of Stroke Alert cases at a university hospital. Demographics, clinical presentation, final diagnosis, and acute interventions were compared between inpatients and those presenting to the emergency department. *Findings:* A total of 1965 Stroke Alert cases were included: 959 (48.8%) were acute cerebrovascular events and 1006 (51.2%) were noncerebrovascular. Hospitalized patients accounted for 489 (24.9%) of Stroke Alerts and patients in the emergency department for 1476 (75.1%). Inpatients were more likely to present with nonfocal neurological deficits (46.2% versus 32.4%, $P <$ .0001) and be diagnosed with noncerebrovascular disorders (62.4% versus 47.5%, $P <$ .0001). Acute interventions other than thrombolysis were delivered in 77.1% of in-hospital cases. Compared to the emergency department, inpatients were more commonly managed with rectification of metabolic abnormalities (21.5% versus 13.7%, $P <$ .001), suspension or pharmacological reversal of drugs (11% versus 3.7%, $P <$ .001), and initiation of respiratory support (13.5% versus 9.3%, P = .01). Inpatients with acute ischemic stroke received intravenous thrombolysis less frequently (4.9% versus 23.9%, $P <$ .001), but the endovascular treatment rate was comparable (9.8% versus 10.3%) to the emergency department. *Conclusion:* Nonfocal neurological deficits and noncerebrovascular disorders are commonly encountered during in-hospital Stroke Alerts. In the inpatient setting, intravenous thrombolysis is rarely delivered while other time-sensitive therapeutic interventions are frequently implemented.

Key Words: In-hospital stroke—Stroke Alert Protocol—stroke code—stroke mimics—intravenous thrombolysis—mechanical hombectomy

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Introduction

Acute neurological deterioration in hospitalized patients is a challenging situation. A variety of neurological and systemic conditions may result in the development of new neurological symptoms. Acute ischemic stroke (AIS) is frequently considered the most critical diagnosis due to the known benefit of time-dependent therapies.[1] Other neurological emergencies in which delayed diagnosis and treatment may result in worsened outcomes include intracranial hemorrhage (ICH), traumatic brain injury, status epilepticus, spinal cord injury, and increased intracranial pressure (ICP).[2] In order to expedite the assessment of hospitalized patients with new neurological symptoms suggestive of AIS, many institutions have implemented an in-hospital Stroke Alert Protocol.[3,4]

In-hospital Stroke Alert Protocols improve the recognition of inpatients with AIS, shorten evaluation time, and hasten management.[5,6] On the other hand, the medical complexity of these patients results in an increased rate of activations due to conditions other than AIS, as well as in a low frequency of thrombolysis delivered mainly due to contraindications.[7-9] Evidence in the use of intravenous tissue plasminogen activator (IV-tPA) for inpatients with AIS suggests similar efficacy when compared to patients presenting from the community.[10,11] However, higher mortality and complication rates have been reported.[12] Little is known about the value of an inpatient Stroke Alert Protocol and the impact on acute management of neurological emergencies beyond thrombolytic therapy.

We aimed to assess the frequency and types of medical conditions other than AIS that triggered the activation of the in-hospital Stroke Alert Protocol and to compare the acute therapeutic interventions implemented by the vascular neurology team in inpatients versus those presenting to the emergency department (ED).

Methods

Study Population

We performed a retrospective analysis of all Stroke Alert Protocol cases from September 2012 to August 2016 at an academic, university hospital. Our institution maintained Joint Commission accreditation as a primary or comprehensive stroke center during the time of the study. The Institutional Review Board of the University of Chicago approved the protocol (IRB-17-1593).

The Stroke Alert Protocol is a system designed to quickly notify the stroke team and other appropriate responders (ie CT techs, stroke nurses, and coordinator) in order to dedicate hospital resources to the immediate diagnosis and treatment of patients with suspected stroke. In our institution, any clinical presentation suggestive of stroke within 6 hours of symptoms onset trigger the Stroke Alert activation. When time of onset is not available, the last time patient is seen at neurological baseline is used as a surrogate. The criteria to activate the Stroke Alert Protocol include: (1) focal weakness or numbness of face, arm, or leg; (2) difficulty speaking or understanding speech; (3) change in vision including visual loss, visual field defects, or diplopia; (4) sudden alteration of consciousness; (5) sudden onset of severe headache, and (6) sudden onset of vertigo or gait disturbance. Special situations that prompt activation at times greater than 6 hours from time of onset include newly discovered ICH on imaging, clinical suspicion of basilar artery thrombosis or large vessel occlusion (LVO), and stroke-like symptoms with fluctuating deficits. The latter is directed to recognize mechanisms of stroke that commonly present with fluctuating symptoms such as, severe vessel stenosis or stuttering lacunar syndromes in which acute treatment might be required. Within 15 minutes of activation, the vascular neurology team first responder (a neurology resident) arrives to patient's bedside, performs an urgent neurological evaluation, orders a head CT, and implements decisions in acute management after discussing their findings with a vascular neurology attending. During the study years, the Stroke Alert Protocol was indistinguishable regardless if activation occurred in the ED or the inpatient setting. The most recent protocol for management of acute stroke in our institution is available as a supplementary appendix (S1).

Starting in September 2013, an educational effort aimed at providers caring for inpatients was launched with the goal of rapidly evaluating all inpatients presenting with new onset neurologic symptoms. Education materials were similar to the ones used to train personnel in the ED. In order to achieve a high sensitivity for stroke recognition, health care personnel (including nurses and doctors) were instructed to have a low threshold for activating the Stroke Alert Protocol irrespective of whether the patient was in the ED or the inpatient setting.

The investigators individually reviewed electronic charts. Patients' demographics and location at the moment of activation (ED versus in-hospital setting) were collected. Reasons for activation were identified from the initial neurology note. The clinical history and neurological exam were reviewed to assess if patients screened positive at presentation for the BE-FAST algorithm (loss of balance, loss of vision, uneven face, limb weakness, and trouble speaking).[13] Neurological deficit severity was determined by the initial National Institutes of Health Stroke Scale. In addition, the clinical course, laboratory data, and studies of neuroimaging were used to confirm the final diagnosis.

Therapeutic Interventions

The decision to deliver IV-tPA in patients with suspected AIS was made by the vascular neurology attending based on the contemporaneous American Heart Association guidelines for management of acute stroke.[14,15] Prior to 2015, endovascular treatment for patients with LVO was offered at the discretion of the vascular neurology attending and the neurointerventionist. In the light of emerging high-quality data on the benefit of stent retrievers for LVO,[16] eligibility criteria for endovascular thrombectomy in patients with occlusion of the internal carotid artery or proximal middle cerebral artery were standardized in 2015 in our center.[15]

We recognized all therapeutic interventions implemented by the vascular neurology team during the Stroke Alert Protocol activation. These interventions were defined as changes in management put into effect emergently in order to correct the pathophysiological mechanism believed to be responsible or contributing to the patient's acute neurological deterioration. They were classified as: (1) cerebral perfusion maneuvers, which included the active management of the arterial blood pressure or augmentation of the cerebral blood flow (ie head of bed flat and induced hypertension)[17]; (2) management of increased ICP, including medical therapies such as transient hyperventilation and hyperosmolar infusions, as well as surgical interventions such as cerebrospinal fluid drainage, intracranial hematoma evacuation, and decompressive craniectomy[18]; (3) use of intravenous antiepileptic drugs (AEDs); (4) correction of metabolic derangements, defined as the rapid correction of metabolic parameters thought to be responsible for patient's symptoms[19]; (5) drug discontinuation and pharmacological reversal of a medication or illicit drug (ie naloxone for opiate intoxication or anticoagulation reversal in patients with ICH), and (6) airway management and respiratory support, defined as any active intervention (ie endotracheal intubation and invasive and noninvasive positive pressure ventilation) meant to correct the respiratory status of the patient during the initial neurological assessment.[20]

Statistical Analysis

Data analyses were carried out by using STATA version 15 (College Station, TX). Descriptive statistics are presented as means with standard deviations or medians with interquartile ranges for continuous variables and as percentages for categorical variables. In univariate analyses, continuous variables were compared by linear models and categorical variables by chi-square or the Fisher exact test as appropriate. Reliability of the screening tool BE-FAST for the detection of AIS was assessed by calculating its sensitivity and specificity. Differences were considered statistically significant at $P < .05$.

Results

The Stroke Alert Protocol pager was activated 2012 times during the study period. Of these, 1965 were included in the analysis. In the remaining 47 cases, the primary team cancelled 21 due to rapid resolution of symptoms, in 13 the Stroke Alert pager was activated by error, 8 had cardiac arrest before the neurology team arrived to bedside, and 5 left the hospital against medical advice before completing neurological assessment.

The educational campaign aiming increase stroke recognition awareness introduced in 2013 resulted in a gradual increase in the number of Stroke Alerts per year (Table 1). Among Stroke Alert cases, the fraction of inpatient activations increased significantly during the study years, as did the cases diagnosed with noncerebrovascular disorders. The proportion of patients with AIS receiving intravenous thrombolysis did not increase while the fraction of AIS patients having endovascular thrombectomy expanded just modestly.

From the included cases, 489 (24.9%) were activated in hospitalized patients and 1476 (75.1%) were activated from the ED. Overall, the mean age was 62.9 ± 16.1 years and 1121 (57%) were women. An acute cerebrovascular event was determined to be the reason for the Stroke Alert activation in 959 (48.8%) cases. These include 567 (28.9%) patients diagnosed with AIS, 232 (11.8%) with transient ischemic attack (TIA), and 160 (8.2%) with acute ICH. The remaining 1006 (51.2%) activations were diagnosed with a noncerebrovascular disorder responsible for presenting neurological symptoms.

Table 2 depicts the characteristics of patients across the site of activation. Focal neurological deficits on presentation were more common in the ED, while nonlocalizing neurological deficits including decreased level of consciousness and acute confusional state were more common in the inpatient setting. The BE-FAST algorithm was positive in 620 out of 652 patients diagnosed with AIS or TIA who presented to the ED (sensitivity .95 C.I .93-.97), whereas only 125 out of 147 cases of in-hospital AIS or TIA screened positive (sensitivity .85 CI. .77-.90).

Table 3 summarizes the noncerebrovascular diagnoses yielded by the Stroke Alert Protocol. Seizure was the single most common diagnosis, followed by encephalopathy secondary to systemic diseases or metabolic derangements, hypotension or cardiac failure, and encephalopathy

Table 1. *Site of Stroke Alert activation, final diagnosis and rate of reperfusion interventions across the years of study*

	September 2012 to August 2013 n = 374	September 2013 to August 2014 n = 410	September 2014 to August 2015 n = 529	September 2015 to August 2016 n = 652	*P value*
Emergency department, n (%)	299 (79.9)	312 (76.1)	413 (78.1)	452 (69.3)	
In-hospital Stroke Alerts, n (%)	75 (20.1)	98 (23.9)	116 (21.9)	200 (30.7)	.0003
Acute ischemic stroke, n(%)	137 (36.6)	110 (26.8)	139 (26.3)	181 (27.8)	.003
Transiet ischemic attack, n (%)	39 (10.4)	65 (15.9)	55 (10.4)	73 (11.2)	.04
Intracranial hemorrhage, n (%)	30 (8)	33 (8)	38 (7.2)	59 (9)	.71
Noncerebrovascular diagnosis, n (%)	168 (44.9)	202 (49.3)	297 (56.1)	339 (52)	.0079
Intravenous thrombolysis, n (%)*	39 (28.5)	23 (20.9)	39 (28.1)	39 (21.5)	.29
Mechanical thrombectomy, n (%)*	10 (7.3)	10 (9.1)	18 (12.9)	20 (11)	.44

*Percentage of patients with diagnosis of acute ischemic stroke.

Table 2. *Clinical presentation and diagnoses of Stroke Alerts activations in hospitalized patients versus those presenting to the emergency department*

	Total Stroke Alerts (n = 1965)	In-hospital Stroke Alerts (n = 489)	ED Stroke Alerts (n= 1476)	*P value*
Age, mean ± SD	62.9 ± 16.1	61.6 ± 17.3	63.3 ± 15.6	.042
Women, n (%)	1121 (57)	257 (52.6)	864 (58.5)	.0237
Focal neurological deficit, n (%)	1266 (64.4)	263 (53.8)	1003 (68)	<.0001
Impaired language, n (%)	114 (5.8)	22 (4.5)	92 (6.2)	.1897
Slurred speech, n(%)	93 (4.7)	19 (3.9)	74 (5)	.3711
Ataxia, vertigo and/or dizziness, n (%)	46 (2.3)	3 (.6)	43 (2.9)	.0017
Transient loss of consciousness, n(%)	75 (3.8)	25 (5.1)	50 (3.4)	.11
Decreased level of consiousness, n (%)	228 (11.6)	101 (20.7)	127 (8.6)	<.0001
Acute confussional state, n (%)	139 (7.1)	56 (11.5)	83 (5.6)	<.0001
Headache, n (%)	9 (.5)	0 (0)	9 (.6)	.1233
NIHSS, median (IQR)	5 (10)	7 (14)	4 (9)	<.0001
Acute ischemic stroke, n(%)	567 (28.9)	102 (20.9)	465 (31.5)	<.0001
Transiet ischemic attack, n (%)	232 (11.8)	45 (9.2)	187 (12.7)	.048
Intracranial hemmorrhage, n (%)	160 (8.1)	37 (7.6)	123 (8.3)	.6547
Non-cerebrovascular diagnosis, n (%)	1,006 (51.2)	305 (62.4)	701 (47.5)	<.0001

associated with systemic infection. Functional disorders represented 10.3% of noncerebrovascular diagnoses and 5.3% of all Stroke Alerts. The departments with higher positive predictive value for in-hospital cerebrovascular events after activating the Stroke Alert pager were vascular surgery, cardiology, and cardiothoracic surgery (Table 4).

Acute interventions with IV-tPA or thrombectomy were delivered in 163 (8.3%) out of the 1965 Stroke Alert activations analyzed. Of these, 105 (5.4%) were IV-tPA alone, 23 (1.2%) endovascular treatment only, and 35 (1.8%) IV-tPA followed by endovascular thrombectomy. When analyzed separately those patients with confirmed diagnosis of AIS, 139 out of 567 (24.5%) received acute reperfusion interventions: 81 (14.3%) IV-tPA alone, 23 (4.1%) endovascular treatment only, and 35 (6.2%) IV-tPA followed by endovascular thrombectomy. Patients with in-hospital AIS were less likely to receive IV-tPA when compared to ED patients. However, AIS cases occurring in the

Table 3. *Non-cerebrovascular diagnoses in patients evaluated through the Stroke Alert Protocol according to the site of activation*

	Total Stroke Alerts (n = 1006)	In-hospital Stroke Alerts (n = 305)	ED Stroke Alerts (n = 701)	*P value*
Neurological diagnoses, n (%)	501 (49.8)	119 (39)	382 (54.5)	<.0001
Seizure, n (%)	253 (25.1)	69 (22.6)	184 (26.2)	.2542
Migraine and other primary headaches, n (%)	63 (6.3)	3 (1)	60 (8.6)	<.0001
Central nervous system structural lesions, n (%)	59 (5.9)	16 (5.2)	43 (6.1)	.6892
Central nervous system infection, n (%)	9 (.9)	3 (1)	6 (.9)	1
Dementia and delirium, n (%)	18 (1.8)	5 (1.6)	13 (1.9)	1
Cranial nerves, peripheral nervous system and muscular disorders, n (%)	49 (4.9)	9 (3)	40 (5.7)	.088
Peripheral vertigo, n (%)	10 (1)	0 (0)	10 (1.4)	.0374
Exacerbation of previous stroke, n (%)	40 (4)	14 (4.6)	26 (3.7)	.6315
Non-neurological diagnoses, n (%)	505 (50.2)	186 (61)	319 (45.5)	<.0001
Encephalopathy due to systemic disease, respiratory insufficiency or metabolic derangements, n (%)	141 (14)	59 (19.3)	82 (11.7)	.0019
Encephalopathy secondary to ETOH or illicit drugs, n (%)	25 (2.5)	1 (.3)	24 (3.4)	.0017
Encephalopathy secondary to systemic infections, n (%)	82 (2.2)	35 (11.5)	47 (6.7)	.0157
Hypertensive crisis, n (%)	20 (2)	2 (.7)	18 (2.6)	.0496
Hypotension, syncope or cardiac failure, n (%)	96 (9.5)	41 (13.4)	55 (7.8)	.0078
Medications adverse effects, n (%)	37 (3.7)	25 (8.2)	12 (1.7)	<.0001
Functional neurological disorder, n (%)	104 (10.3)	23 (7.5)	81 (11.6)	.0706

Table 4. *Final diagnosis of in-hospital Stroke Alert activations by primary service*

Primary service	Total in-hospital Stroke Alerts (n = 489)	PPV (95% C.I.)*
Internal medicine, n (%)	143 (29.2)	.25 (.18-.33)
Cardiology, n (%)	90 (18.4)	.60 (.50-.70)
Hematology/oncology, n (%)	50 (10.2)	.32 (.20-.47)
Medical ICU, n (%)	46 (9.4)	.24 (.13-.39)
Cardiothoracic surgery, n (%)	45 (9.2)	.49 (.40-.64)
General surgery, n (%)	30 (6.1)	.37 (.21-.56)
Neurology, n (%)	29 (5.9)	.34 (.19-.54)
Vascular surgery, n (%)	17 (3.5)	.65 (.39-.85)
Obstetric/gynecology, n (%)	12 (2.5)	.33 (.11-.65)
Pediatrics, n (%)	12 (2.5)	.25 (.07-.37)
Neurosurgery, n (%)	8 (1.6)	.38 (.10-.74)
Orthopedic surgery, n (%)	7 (1.4)	.43 (.12-.80)

*Positive predictive value and 95% confidence interval for acute cerebrovascular events.

inpatient setting were equally likely to receive endovascular treatment (Fig 1).

Of 451 patients with AIS that did not receive IV-tPA, 52.1% were outside therapeutic window, 25.3% had minor neurological deficits, 11.1% had history of hemorrhage or active bleeding diathesis, 3.1% had a recent major surgery, 1.3% had seizures at onset, and 7.1% had other contraindications (age < 18 years, intracranial vascular malformations, uncontrolled blood pressure, recent myocardial infarction, massive tissue ischemic changes on CT, or consent declined by family). When compared to patients in the ED, inpatients were less likely to be excluded from IV-tPA therapy for being outside the therapeutic window (39.2% versus 55.6%, $P = .006$) or for minor neurological deficits (10.3% versus 29.4%, $P = .0002$), whereas contraindications for IV-tPA such as history of hemorrhage or bleeding diathesis (18.6% versus 9%, $P = .013$) and recent major surgery (14.4% versus 0%, $P < .00001$) were more frequent.

Independent of thrombolytic therapies, the vascular neurology team implemented acute therapeutic interventions in 1528 (77.8%) out of the 1965. Of these, 1083 (55.1%) underwent cerebral perfusion maneuvers, 323 (16.4%) received intravenous AEDs, 307 (15.6%) had rapid correction of metabolic derangements, 203 (10.3%) were started on respiratory support, 192 (9.8%) required management of increased ICP, and 109 (5.5%) had suspension or pharmacological reversal of a drug or toxic agent. The frequency of acute therapeutic interventions other than thrombolysis was not different between hospitalized patients and those presenting to the ED (77.1% versus 78%). When compared to the Stroke Alerts activated in the ED, inpatients were more commonly managed with rectification of metabolic abnormalities, suspension or

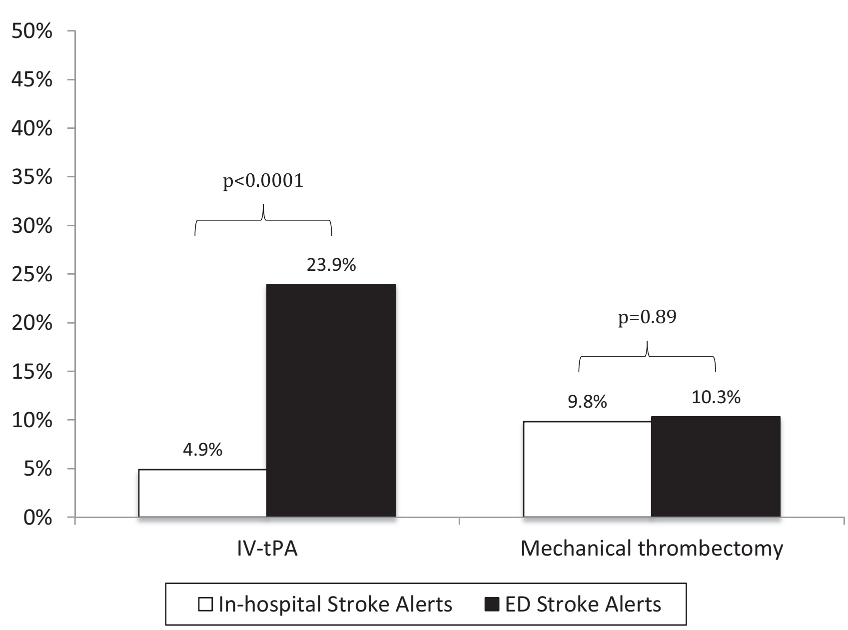

Figure 1. *Acute reperfusion interventions in patients with final diagnosis of acute ischemic stroke evaluated through the Stroke Alert Protocol.*

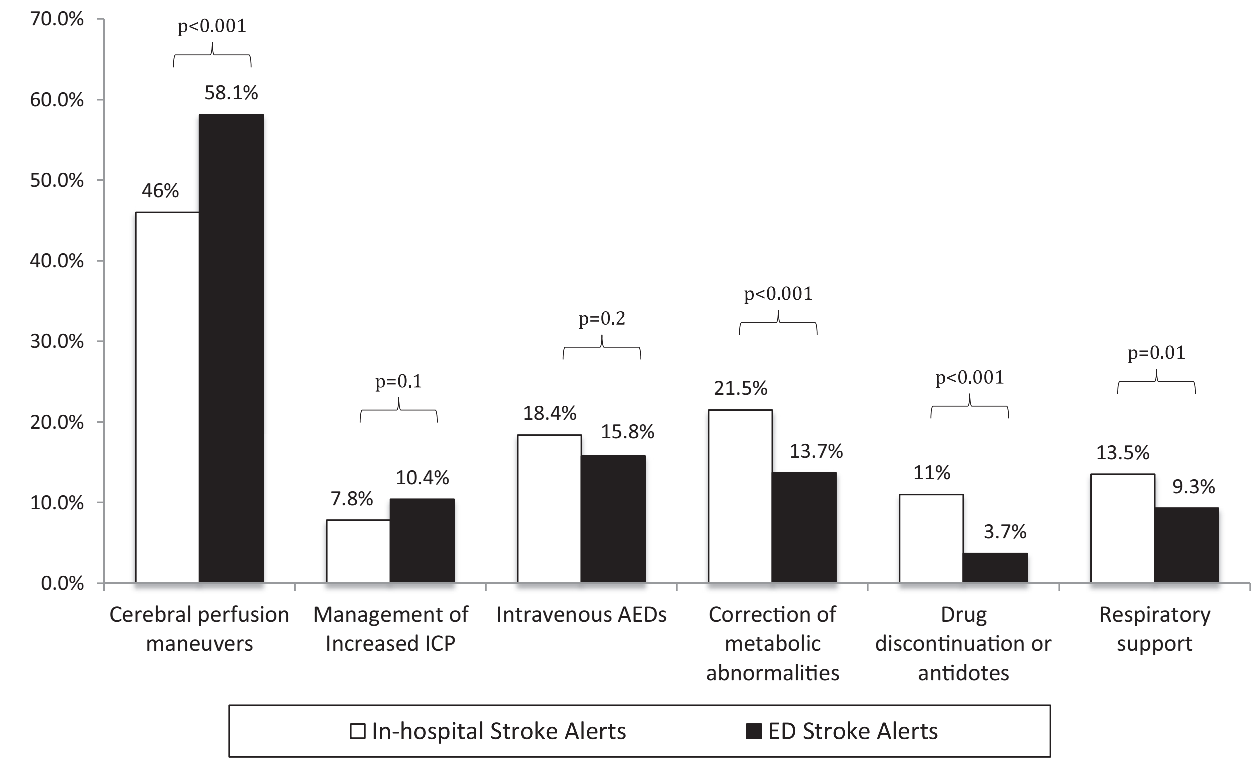

Figure 2. *Acute therapeutic interventions other than reperfusion interventions in patients evaluated through the Stroke Alert Protocol.* Abbreviations: AEDs, antiepiletic drugs; ICP, intracranial pressure.

pharmacological reversal of drugs, and initiation of respiratory support Fig 2.

Discussion

We present data on initial clinical symptoms, final diagnosis, and acute therapeutic interventions implemented in a large cohort of patients evaluated through the Stroke Alert Protocol in a tertiary care center and compare the cases activated in the inpatient setting versus those presenting to the ED. Previous studies have addressed the differences across the site of activation of the Stroke Alert Protocol.[7-9,21-25] In our study, similar to others, we found that inpatients who developed acute neurologic deterioration and were evaluated through the Stroke Alert Protocol: (1) frequently presented with nonlocalizing neurological symptoms such as mental status changes[8]; (2) developed severe neurological deficits as measured by the National Institutes of Health Stroke Scale[8,21,25]; (3) were frequently diagnosed with conditions other than AIS[7,8,21,22]; (4) were less likely to receive IV-tPA[9,23,24,25]; and (5) were eligible for mechanical thrombectomy at a significant rate.[26]

In distinction from previous reports[7-9] our study showed: (1) lower rate of patients with confirmed diagnosis of cerebral ischemia presenting with focal neurological deficits (BE-FAST positive) in the inpatient setting; (2) significant number of inpatients presenting with acute neurological deterioration due to ICH; and (3) common time-sensitive therapies besides thrombolysis implemented by the vascular neurology team.

Ischemic stroke as a secondary diagnosis during hospitalization is not uncommon[25,27,28] and as a result, institutions have been encouraged to implement organized emergency responses to rapidly identify and treat these patients.[3] Recognition and assessment of stroke-like symptoms in the in-hospital population is challenging, especially for non-neurologist. Common factors that obscure the initial assessment of inpatients with acute neurological deterioration are medication effects, orthopedic injuries, surgical procedures and hemodynamic, and respiratory instability.[27] Our data suggest that simple screening tools for recognition of AIS in the prehospital setting such as the BE-FAST algorithm might not be sensitive enough to identify inpatients with acute ischemic strokes that could benefit from acute reperfusion therapies, and therefore, neurologic expertise may be needed to identify inpatients that would have otherwise been missed. In addition, we found a higher fraction of patients with acute cerebrovascular emergencies when the Stroke Alert was activated on services such as cardiology, cardiothoracic surgery, and vascular surgery. This suggests that certain medical services may require more vigilant monitoring of the neurological exam to avoid late recognition of neurological emergencies.

The educational campaign implemented at our institution aimed to set a lower trigger for Stroke Alert activation in order to provide acute neurological evaluation to all patients with acute neurologic symptoms regardless if they presented to the ED or were hospitalized. This resulted in an expected higher number of activations and diagnoses other than AIS. However, it is our observation that many of non-AIS conditions required rapid assessment and treatment. In the inpatient setting, out of 69 patients who presented with seizures, 57 were diagnosed as Status Epilepticus and treated with intravenous AEDs and 4 out of 16 patients with structural brain lesions required acute management of increased ICP. Simple maneuvers such as restoration of cerebral blood flow in hypotensive patients and correction of metabolic derangements (ie hypoglycemia) were also valuable interventions in which recognition of the offending agent during the initial neurological evaluation played an important role. Respiratory support was required in 13.5% of inpatients evaluated through the Stroke Alert Protocol. Airway management with special attention to preservation of cerebral blood flow, ICP, ventilation settings, and the use of sedative agents based on patient's neurological status often requires the input of physicians specialized in acute care neurology.[20]

Thirty-seven (7.6%) inpatients were found to have ICH and benefited from expedited neurological care (ie appropriate blood pressure and ICP management, anticoagulation reversal, etc.). Patients who developed ICH as a complication during hospital admission represent a unique population with devastating outcomes,[29] which is beyond the scope of the present study. On the other hand, we found a considerable proportion of in-hospital Stroke Alerts activated for chronic symptoms of previous brain lesions, expected medication effects (ie sedatives), and functional neurological disorders (2.9%, 5.1%, and 4.7%, respectively) in whom the intervention from the vascular neurology team was minimal and nonurgent. Education to health care providers should emphasize the establishment of neurological baseline at admission, review of current list of medications, and recognition of nonphysiological symptoms to avoid low yield activations.

The reported administration rate of IV-tPA for in-hospital strokes ranges between 2.7% and 14.7%,[9,23,24,25,30] which is lower compared to the rate of IV-tPA used in patients arriving to the ED $\leq$ 2 hours of symptom onset (22.1%).[31] Similar to the study of Vera and colleagues, our study showed that the most common contraindication for IV-tPA in hospitalized patients was being outside the therapeutic window. Hospitalized patients with AIS should have an advantage as that prehospital delays are not present, however late recognition and assessment are frequent.[6,32] In addition to well-organized Stroke Alert Protocols, frequent neurological examinations in high-risk patients by nurses with neurologic competencies could prevent delayed identification.

Mechanical thrombectomy improves patient outcomes compared to IV-tPA alone in patients with intracranial LVO.[16] Moreover, there is encouraging data on the benefit of thrombectomy with stent retrievers in a subset of patients up to 24 hours of symptoms onset.[33,34] Endovascular treatment for patients with in-hospital AIS provides an opportunity to increase the proportion of patients that could have access to recanalization procedures that otherwise would not be able to receive treatment with IV-tPA due to contraindications. Common scenarios in the inpatient setting in which endovascular intervention could be the first-line treatment are after cardiac surgery, unknown time of symptoms onset due to anesthesia (with the use of advanced imaging), and use of anticoagulants.[35-37] Our data support the notion that the rate of eligibility for endovascular interventions is similar in patients with in-hospital AIS than in those presenting to the ED. In the appropriate patient population, routine screening for LVO and consideration of advanced perfusion imaging to detect mismatch between penumbra and infarct size should probably be part of in-hospital Stroke Alert Protocols.

Our study has several limitations. First, as a retrospective analysis it was restricted by the accuracy of chart documentation. Nevertheless, individual chart review by neurologist physicians enhanced the reliability of data interpretation. Second, our results describe the experience of a single tertiary care university hospital and cannot be entirely generalized to other settings such as community health care institutions. In addition, Stroke Alert Protocols are not standardized and may vary by hospital, limiting the generalizability of this study. Third, even though we had uniform criteria for stroke alert activation among the years of the study, we don't have the proportion of cases that were activated under each of those specific criteria such as ICH found on brain imaging or suspicion of basilar thrombosis in an extended window beyond 6 hours. Fourth, we did not identify inpatients with acute neurological decline in which the Stroke Alert Protocol was not activated. Finally, further comparisons of outcomes on patients who had expedited evaluation by the stroke team, and received acute management beyond thrombolysis versus those who did not would provide further evidence on the benefit of having an in-hospital Stroke Alert Protocol.

In summary, we found that a Stroke Alert Protocol aimed to assess inpatients with acute neurological deterioration was exposed to a variety of neurological and systemic emergencies other than AIS. Conditions that triggered the Stroke Alert activation in the inpatient setting were different from the ED. These conditions were likely to have benefited from appropriate triage, timely recognition of the cause, and implementation of acute interventions other than thrombolysis. A low threshold for in-hospital Stroke Alert activation resulted in an increased workload for the vascular neurology team without increasing the rate of IV-tPA administration while delivering a reasonable rate of endovascular intervention.

Further studies are needed on resource utilization and appropriate composition of in-hospital rapid response teams, to determine what types of care settings benefit most from rapidly available neurologic expertise in the evaluation and management of inpatients presenting with acute neurologic decompensation.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jstrokecerebrovasdis.2019.02.001.

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