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Factors Predicting Misidentification of Acute Ischemic Stroke and Large Vessel Occlusion by Paramedics

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Abstract: The emergence of thrombectomy for large vessel occlusions has increased the importance of accurate prehospital identification and triage of acute ischemic stroke (AIS). Despite available clinical scores, prehospital identification is suboptimal. Our objective was to improve the sensitivity of prehospital AIS identification by combining dispatch information with paramedic impression. We performed a retrospective cohort review of emergency medical services and hospital records of all patients for whom a stroke alert was activated in 1 urban, academic emergency department from January 1, 2018, to December 31, 2019. Using admission diagnosis of acute stroke as outcome, we calculated the sensitivity and specificity of dispatch and paramedic impression in identifying AIS and large vessel occlusion. We identified factors that, when included together, would improve the sensitivity of prehospital AIS identification. Two-hundred twenty-six stroke alerts were activated by emergency department physicians after transport by Indianapolis emergency medical services. Forty-four percent (99/226) were female, median age was 58 years (interquartile range, 50–67 years), and median National Institutes of Health Stroke Scale was 6 (interquartile range, 2–12). Paramedics demonstrated superior sensitivity (59% vs. 48%) but inferior specificity (56% vs. 73%) for detection of stroke as compared with dispatch. A strategy incorporating dispatch code of stroke, or paramedic impression of altered mental status or weakness in addition to stroke, would be 84% sensitive and 27% specific for identification of stroke. To optimize rapid and sensitive stroke detection, prehospital systems should consider inclusion of patients with dispatch code of stroke and provider impression of altered mental status or generalized weakness.

Key Words: emergency medical services, large vessel occlusion, stroke

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Early detection of acute stroke by paramedics in the prehospital setting facilitates appropriate triage and rapid treatment of this time-critical condition. Large vessel occlusions (LVOs) can be effectively treated with mechanical thrombectomy, which is only available at some facilities, and which improves functional outcomes in patients with LVO.[1–5] Most strokes are not LVO, however, and patients with acute non-LVO strokes benefit from rapid transport to the nearest thrombolysis-capable facility, which is not generally a thrombectomy-capable comprehensive stroke center (CSC).[6] Emergency medical services (EMS) providers must therefore accurately identify and transport patients with strokes to appropriate receiving centers, which may be the nearest primary stroke center or may be a more distant CSC.

Most EMS systems approach this dilemma either by transporting all patients with suspected stroke to the nearest thrombolysis-capable facility, leaving subsequent transfer of LVO patients to the emergency physician, or by using prehospital stroke severity scales to identify patients with potential LVO for transport directly to a CSC, often bypassing the nearest thrombolysis-capable facility.[7] The most recent American Heart Association guidelines recommend a validated stroke screen and stroke severity score to assess for possible LVO and transport to a CSC if: last known well time is less than 24 hours, transport time to CSC will not disqualify a patient for thrombolysis, and total transport time to the CSC is under 30 minutes.[8] Systems applying this approach have demonstrated improved times from scene departure to thrombectomy and improved patient functional outcomes.[9] However, meta-analyses demonstrate that only 26%–51% of patients identified by stroke severity scales as potential LVOs are in fact diagnosed with LVOs.[7,10] Furthermore, stroke severity scores are limited in that they are only applied when a stroke is suspected by prehospital providers. Thus, if an EMS system has limited sensitivity for stroke detection, stroke and LVO detection will necessarily be similarly limited.

While many studies have focused on scores to optimize prehospital identification of acute ischemic stroke (AIS) and LVO, few have explored the characteristics of stroke and LVO cases missed by EMS. In this study, we identified all stroke alerts in 1 academic urban emergency department (ED) after transport by Indianapolis EMS (IEMS). We characterized paramedic sensitivity and specificity for identifying stroke and LVO with their protocol-directed Cincinnati Prehospital Stroke Scale (CPSS) and Rapid Arterial oCclusion Evaluation (RACE) scale for identification of LVO. We identified the dispatch codes and paramedic impressions associated with missed AISs and suggest a strategy to optimize sensitivity for prehospital stroke detection.

METHODS

This study was deemed exempt from review by the Indiana University Institutional Review Board, protocol number 2003587456.

Study Design and Setting

We retrospectively reviewed the in-hospital and prehospital electronic medical records from January 1, 2018, to December 31, 2019, for every patient transported by IEMS on whom a stroke alert (ie, potential acute stroke) was activated by an ED physician based on patient evaluation in 1 academic urban ED (Eskenazi Hospital).

In Marion County, Indianapolis, EMS care is provided to the population of about 900,000 by IEMS as well as paramedics based at fire stations.[8] IEMS operates 31 ambulances staffed with both

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advanced life support (ALS) and basic life support (BLS) providers at peak times and completes 85,000 transports per year. The IEMS protocol directs both BLS and ALS providers to obtain a blood glucose level and to perform the CPSS on any patient with suspected stroke. There are no specific mandates for symptoms that trigger the CPSS, but the protocol does suggest that patients with strokes may have "fallen, (be) unable to walk, have new balance problems or (have) acute altered level of consciousness." The protocol further directs that RACE be recorded for all patients with suspected stroke, though this scale is not currently used by IEMS to direct transport. Emergency Medical Dispatch (EMD) is performed using Association of Public-Safety Communications Officials guidecards.

Patient and Public Involvement

No patient was involved.

Measures

We collected demographic data (gender and age), EMS run descriptors (location of patient pick-up, date of service, response and transport times, dispatch code, prehospital primary impression, level of service, prehospital CPSS and RACE), hospital evaluation and treatment data (physician National Institute of Health Stroke Scale, thrombolysis, thrombectomy), and diagnosis of ischemic (not hemorrhagic) stroke on hospital admission as recorded in stroke neurology notes. Noncontrast computed tomography (CT) was completed on all patients with suspected stroke. The stroke neurologist determined the need for CT angiography or magnetic resonance imaging. Data were collected in Excel (Microsoft Corporation, Redmond, WA).

Analysis

We described count frequencies and percentages and calculated continuous variable medians and interquartile ranges (IQRs). Chi-square compared counts, and independent-sample t test compared continuous variables.

We calculated the sensitivity and specificity of dispatch and paramedic impressions of stroke in identifying strokes definitively diagnosed in the ED. Paramedic-suspected strokes that were not called as a stroke alert by the ED physician were considered false positives. We identified the dispatch codes and paramedic impressions associated with prehospital false negatives and calculated the test characteristics of alternative strategies for prehospital stroke identification incorporating non-stroke dispatch and paramedic impressions. Data analysis performed with SAS University Edition (SAS Institute, Inc., Cary, NC).

RESULTS

Between January 1, 2018, and December 31, 2019, IEMS transported 45,339 patients to Eskenazi Hospital. Of those, 211 had a paramedic impression of stroke. Median public-safety answering point call to dispatch time was 1 minute (IQR, 0–2 minutes), median scene time was 14 minutes (IQR, 11–18 minutes), and median transport time to Eskenazi ED was 11 minutes (IQR, 8–14 minutes). Patients were transported by ALS in 199 (88%) cases and by BLS in 26 (12%) cases. Among all stroke codes, using admission diagnosis of stroke as the gold standard, paramedics demonstrated superior sensitivity (58% vs. 48%) but inferior specificity (56% vs. 73%) for detection of stroke as compared with dispatch (Table 1).

When strokes were not identified in the prehospital setting, the most common dispatch codes were sick person (21), chest pain (12), and syncope (10). When paramedics failed to identify AIS, their most common impressions were altered mental status (14), generalized weakness (11), and chest pain (6) (Table 2).

Using either dispatch or paramedic impression of stroke would improve sensitivity to 77.2% (115/149) at a specificity of 46.8% (36/77) among stroke codes. Identifying possible strokes with paramedic impressions of stroke, altered mental status, or generalized weakness would achieve 75.2% sensitivity (112/149) at a specificity of 31.2% (24/77). A strategy using either dispatch code of stroke, or prehospital impression of stroke, altered mental status, or weakness would be 83.9% sensitive (125/149) and 27.3% specific (21/77) for identification of stroke, among patients activated as stroke alerts. When calculated among all patients dispatched as stroke or with an EMS primary provider impression of stroke, altered mental status, or weakness, the specificity would improve to 65.9% (29,812/45,214) for identification of stroke.

RACE was documented for 47% (106/226) of stroke alert patients; paramedics documented "unable to complete" RACE in 5% (12/226). In our system, RACE ≥ 5 was 71% sensitive and 57% specific for identification of an LVO confirmed by CT angiography. All 11 patients determined to have LVO by CT angiography received mechanical thrombectomy. Of the patients who had LVOs, 8 (73%) had a primary provider impression of stroke. The other 3 had various primary provider impressions and dispatch codes (Table 3).

Applying RACE to all patients with dispatch code of stroke or paramedic impression of stroke, altered mental status or generalized weakness would have potentially identified 1/11 (9%) additional LVO in the prehospital setting.

Of the 211 patients with paramedic impression of stroke, ED physicians activated 122 (57.8%) stroke alerts upon arrival in the ED.

TABLE 1. Sensitivity and Specificity for Identification of Acute Ischemic Stroke by Dispatch and Paramedics

Test Characteristics	Dispatch	Paramedics
Sensitivity	47.7%	58.4%
Specificity	72.7%	54.5%

TABLE 2. When Strokes Were Not Identified by (A) Dispatch or (B) Paramedic, Impressions Were Varied, But Most Commonly "Sick Person" and "Altered Mental Status"

(A) Dispatch Code	Patients With Strokes That Were Not Identified (%)
Sick person	21 (9.3)
Chest pain	12 (5.3)
Syncope	10 (4.4)
Diabetic problem	8 (3.5)
(B) Primary Provider Impression	Patients With Strokes That Were Not Identified (%)
Altered mental status	14 (6.2)
Generalized weakness	11 (4.9)
Chest pain	6 (2.7)
Dizziness	4 (1.8)
Diabetic hypoglycemia	3 (1.3)
Headache	3 (1.3)
Seizure	2 (0.9)

TABLE 3. LVO Not Identified As Strokes by the Prehospital Provider

Case	Dispatch Code	Primary Provider Impression
Patient 1	Stroke	Altered mental status
Patient 2	Breathing problem	Acute respiratory distress
Patient 3	Psych problem	Behavioral/psych episode

The other 89 (42.2%) were determined by the ED physician to not have sustained a stroke. There were an additional 104 ED stroke alert activations after transport by IEMS that were not identified as strokes by the IEMS provider (Fig. 1). Of the 122 patients activated as stroke alerts in the ED, 99 (44%) were female, median age was 58 years (IQR, 50–67 years), median National Institute of Health Stroke Scale was 6 (IQR, 2–12).

One-hundred forty-nine (65.9%) of ED stroke alerts were admitted with a diagnosis of AIS, and 77 (34.1%) were determined not to be strokes after imaging and evaluation by a stroke neurologist (Table 4). Of the 149 patients admitted for stroke, 44 (30%) patients received thrombolysis, and 11 (7%) underwent thrombectomy for LVO. All patients found to have an LVO underwent mechanical thrombectomy.Although our efforts were based on a convenience sample of patients taken to 1 ED, we compared characteristics of potential stroke patients taken to Eskenazi with those taken to other hospitals. During the study period, 1572 patients were transported to any hospital by IEMS with paramedic primary impression of stroke. We noted differences in demographics. Patients transported to Eskenazi Hospital versus any other hospital were significantly younger (median [IQR] age = 59.0 [50.0–67.0] vs. 68.0 [58.0–70.0]; $P < 0.001$), more often male (116 [56.0%] vs. 595 [43.5%]; $P < 0.001$), and less often White (87 [42.0%] vs. 860 [62.8%]; $P < 0.001$). However, we did not find significant difference in CPSS positivity (182 [87.9%] vs. 1157 [84.5%]; $P = 0.212$) (Supplemental Table 1, http://links.lww.com/HPC/A244).

DISCUSSION

Rapid and accurate prehospital identification of AIS is critically important, given the time-sensitive nature of available treatments,[7] and is associated with improved outcomes.[10,11] The availability of CSCs that offer endovascular therapy for patients with LVO is limited as compared with more common primary stroke centers that can provide medical thrombolysis.[12] Given that endovascular therapy for LVO is superior to medical therapy alone,[1,7]

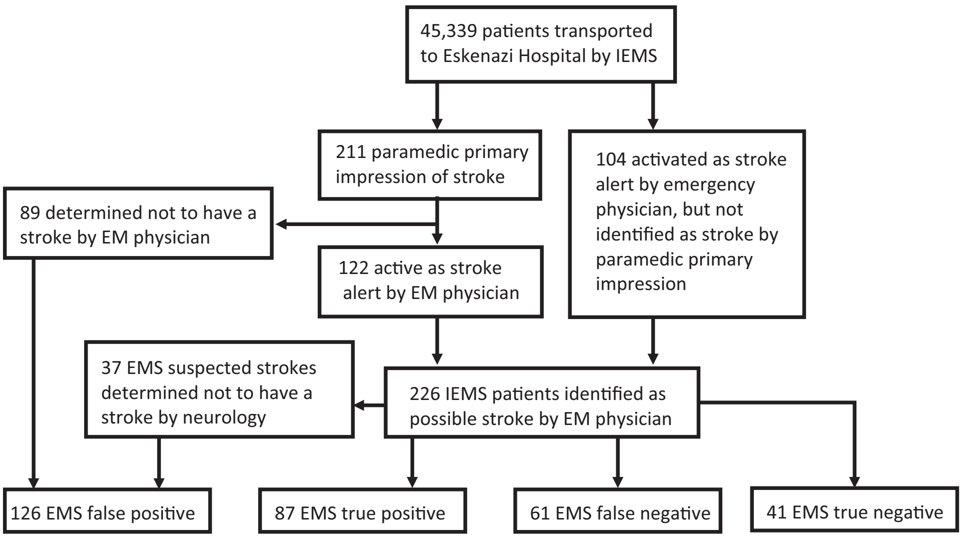

FIGURE 1. Flow chart of patients identified for the study. EM indicates Emergency medicine.

TABLE 4. ED Stroke Alert Patient Demographic and Prehospital Factors Stratified by Neurologist Confirmed Acute Ischemic Stroke Status

	Confirmed Stroke		No Stroke		
Patient Factors	**Median**	**IQR**	**Median**	**IQR**	***P***
Age	59.5	51.3–67.0	56.5	44.8–65.3	0.083
NIHSS	5.0	2.0–10.0	5.5	2.0–14.0	0.358
Sex	n (%)	95% CI	n (%)	95% CI	0.574
Male	62 (41.9)	33.9–49.8	36 (46.2)	35.1–57.2	
Female	86 (58.1)	50.2–66.1	42 (53.8)	42.8–64.9	
CPSS					0.181
Positive	95 (64.5)	56.5–71.9	41 (52.6)	41.5–63.6	
Negative	15 (10.1)	5.3–15.0	8 (10.3)	3.5–17.0	
Not performed	38 (25.7)	18.6–32.7	29 (37.2)	26.5–47.9	
Paramedic impression stroke					0.103
Yes	87 (58.8)	50.9–66.7	37 (47.4)	36.4–58.5	
No	61 (41.2)	33.3–49.1	41 (52.6)	41.5–63.6	
Dispatch code was stroke					<0.01
Yes	71 (48.0)	39.9–56.0	21 (26.9)	17.1–36.8	
No	77 (52.0)	44.0–60.1	57 (73.1)	63.2–82.9	

CI indicates confidence interval; NIHSS, National Institute of Health Stroke Scale.

identification of the subset of stroke patients experiencing LVO in the prehospital setting is essential to directing appropriate transport destination decisions. We described the ability of EMS dispatch and paramedics to identify strokes in the prehospital setting in 1 large urban EMS system. The rate of missed stroke by both EMD and prehospital professionals is higher than the ED.[13] Our data suggest combinations of dispatch and paramedic impressions that could improve the prehospital detection of AIS and marginally improve prehospital detection of LVO.

Numerous prehospital stroke scales aim to identify patients experiencing LVO, and in our system, both RACE and the CPSS are used. The RACE scale demonstrates similar predictive performance to the CPSS, Los Angeles Motor Screen, and Vision, Aphasia, and Neglect instruments,[14] but may have inferior performance to other prehospital stroke scales.[15] The sensitivity of paramedics in this study to identify AIS was similar to previously reported sensitivities for large metropolitan EMS systems,[16–20] and IEMS utilization of the RACE score demonstrated similar sensitivity and specificity as previously reported.[21–23] Failure to recognize a patient having a stroke likely represents a significant barrier to applying a prehospital stroke scale. Our findings suggest that in addition to primary provider impression of stroke, all EMS responses with a dispatch of stroke or with primary provider impression of altered mental status or weakness should be considered as possible AISs. This underscores the importance of both paramedic and EMD evaluation to identify AIS in the prehospital setting.

While it is not practical to transport every patient with a dispatch or prehospital impression of altered mental status and generalized weakness to a CSC, these are the most common patients in whom AIS is missed, and special attention should be paid to these patients, for whom a more detailed prehospital stroke assessment should be performed, and for whom early hospital notification might be considered. Some over-triage of patients with potential AIS to higher levels of care may be appropriate given the time-sensitive nature of stroke treatment.[24,25]

This study has limitations. The specific features associated with incorrect prehospital impressions cannot be ascertained from the available data. Of the subset of patients with a false-negative EMS primary impression, it is unclear whether a more detailed stroke assessment would have improved detection of LVO. Including only patients transported to an academic center with a CSC may bias the study population toward sicker patients. While there were differences in demographics of patients with paramedic-suspected stroke by transport to the study hospital versus other area hospitals, there was no difference in positivity of CPSS. Expanding the use of a prehospital stroke scale to the most common false-negative dispatch codes and provider impressions should be investigated with a future prospective study and in other EMS systems to ascertain generalizability of our findings.

CONCLUSIONS

Conducting detailed prehospital stroke assessments on patients with dispatch codes of stroke or with prehospital provider impression of altered mental status or weakness in addition to prehospital provider impression of stroke may improve the prehospital detection of AIS. Further prospective research is needed to evaluate this assessment model.

DISCLOSURES

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