Original research

Paramedic utilization of Vision, Aphasia, Neglect (VAN) stroke severity scale in the prehospital setting predicts emergent large vessel occlusion stroke

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ABSTRACT

Background Numerous stroke severity scales have been published, but few have been studied with emergency medical services (EMS) in the prehospital setting. We studied the Vision, Aphasia, Neglect (VAN) stroke assessment scale in the prehospital setting for its simplicity to both teach and perform. This prospective prehospital cohort study was designed to validate the use and efficacy of VAN within our stroke systems of care, which includes multiple comprehensive stroke centers (CSCs) and EMS agencies.

Methods The performances of VAN and the National Institutes of Health Stroke Scale (NIHSS) ≥6 for the presence of both emergent large vessel occlusion (ELVO) alone and ELVO or any intracranial hemorrhage (ICH) combined were reported with positive predictive value, sensitivity, negative predictive value, specificity, and overall accuracy. For subjects with intraparenchymal hemorrhage, volume was calculated based on the ABC/2 formula and the presence of intraventricular hemorrhage was recorded.

Results Both VAN and NIHSS ≥6 were significantly associated with ELVO alone and with ELVO or any ICH combined using χ^2 analysis. Overall, hospital NIHSS ≥6 performed better than prehospital VAN based on statistical measures. Of the 34 cases of intraparenchymal hemorrhage, mean±SD hemorrhage volumes were 2.5±4.0 mL for the five VAN-negative cases and 17.5±14.2 mL for the 29 VAN-positive cases.

Conclusions Our VAN study adds to the published evidence that prehospital EMS scales can be effectively taught and implemented in stroke systems with multiple EMS agencies and CSCs. In addition to ELVO, prehospital scales such as VAN may also serve as an effective ICH bypass tool.

BACKGROUND

Time-dependent therapies for acute ischemic stroke include intravenous thrombolysis (IVT) and mechanical thrombectomy (MT).[1] IVT is considered for all patients with ischemic stroke up to 4.5 hours from last known well (LKW). MT, however, is limited to the ischemic stroke subtype emergent large vessel occlusion (ELVO) and is considered up to 24 hours from LKW. Although IVT is administered at all stroke hospitals, MT is only performed at selective stroke centers that frequently triage ELVO via hub and spoke models and/or Emergency Medical Service (EMS) prehospital bypass protocols. Paramedics may identify ELVO in the field by using a stroke severity screen and then consider bypass to the closest stroke center that offers MT.

Prehospital stroke severity screening facilitates ELVO triage to the most appropriate stroke center and thus optimizes time, treatment options, and good clinical outcomes. Each hour of MT delay is associated with a 5.5% decrease in independent outcome.[2] Thus, the recent American Stroke Association guidelines support the development of prehospital protocols that facilitate transport of probable cases of ELVO stroke to hospitals that offer MT.[3] Results from recent thrombectomy trials[4–6] and real-world data[7] demonstrate a 2 hour MT delay when patients with ELVO are initially directed to a non-thrombectomy stroke center and then transferred to a thrombectomy-capable facility. The majority of delays are often attributed to door-in-door-out (DIDO) times at the transferring center.[7] To minimize this delay, DIDO protocols have been established that streamline communication between the hub and spoke, incorporate cloud-based imaging, and improve access to secondary transport ambulances.[8] Additionally, DIDO times may be further reduced when EMS notifies the spoke of a positive ELVO screen and possible secondary transfer before the patient arrives. On the other hand, secondary transfers may result in bypassing a non-affiliated MT center for the more distant affiliated hub and thus cause an unintended delay. The optimal workings of DIDO protocols and prehospital ELVO triage with a stroke severity scale are variable and likely dependent on regional stroke systems of care.

Important characteristics of a prehospital stroke severity scale include simplicity of teaching and use, reproducibility, accuracy, and validation in both the prehospital setting and external datasets.[9] Numerous scales have been published, but few have been studied with EMS personnel performing the scale in the prehospital setting. To date, only Rapid Arterial oCclusion Evaluation (RACE),[10 11] Los Angeles Motor Scale (LAMS),[12 13] and Cincinnati Prehospital Stroke Severity Scale (C-STAT)[14] have been studied in both prospective prehospital EMS triage and validated in external datasets. The potential shortcomings of these three scales include the need to calculate a score, and additionally for

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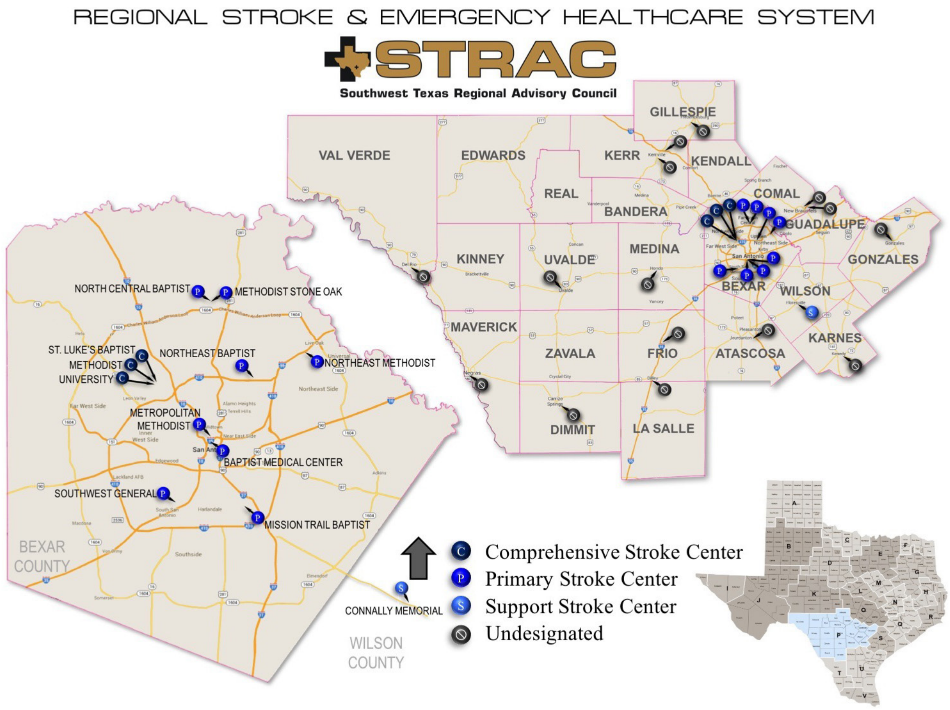

Figure 1 Map of South Texas Regional Advisory Council (STRAC) stroke centers.

RACE and LAMS, the need to test severity of motor weakness. In comparison, the Vision, Aphasia, Neglect (VAN) stroke assessment does not require score calculation or motor severity testing. Although initially published as an ELVO nurse triage in the emergency department (ED),[15] VAN has since been validated in multiple external EMS and hospital datasets[16–18] but has yet to be studied in a prospective prehospital EMS cohort.

We selected VAN to study in the prehospital setting for its simplicity to teach and perform. Because the assessment begins with arm weakness, VAN incorporates well with prehospital EMS stroke workflows that include the Cincinnati Prehospital Stroke Scale (CPSS). This prospective prehospital cohort study was designed to validate the use and efficacy of VAN within our stroke systems of care, which includes multiple comprehensive stroke centers (CSCs) and EMS agencies.

METHODS

Our Regional Advisory Council (RAC) is composed of 22 counties covering 26 000 square miles, with San Antonio and Bexar County as the medical seat of the region (figure 1). Bexar County is composed of 13 primary stroke centers (PSCs), none of which offer MT, and three CSCs that are clustered within a half-mile radius. Currently, there are no thrombectomy-capable stroke centers or Primary Plus Centers in our region. Two EMS systems, San Antonio Fire Department (SAFD) and Acadian Ambulance Service (AAS), transport the majority of stroke patients in the area. The SAFD is a large metropolitan fire department providing emergency medical services, fire protection, and rescue services to a population of 1.53 million residents covering 465 square miles. SAFD is the sole 911 provider for EMS response and transport within the incorporated city limits of San Antonio. AAS is a large private EMS service that is the sole 911 provider for EMS response and transport for the unincorporated areas within Bexar County and several suburban municipalities. Both EMS systems provide paramedic level of care for all high acuity responses. All patient encounters are documented in an electronic Patient Care Record.

The study was submitted under protocol number HSC20170104N to the University of Texas Health San Antonio Institutional Review Board and did not require approval as the project was not regulated research as defined by the Department of Health and Human Services regulations. During a 4-week session, VAN training for medics was performed: in person, via an interactive live video (iLinc), and/or by distribution of recorded material (RAC Brainshark). All medics were required to participate in the 45 min session and complete a 10-question post-quiz to document comprehension. In person instruction was limited to the eight SAFD units in the immediate CSC area and included 63 active paramedics. Medics from the remaining SAFD units were trained by distributed education using the RAC Brainshark online training platform. In addition, more than 100 paramedics from AAS were trained via iLinc. The session was entitled 'EMS Identification of Large Vessel Occlusion (LVO) Stroke' and focused on LVO triage rationale, basic brain anatomy, and how to perform VAN. After each session, medics triaged three fictional LVO cases and then completed a 10-question true or false quiz to demonstrate mastery of the subject. Educational materials were also readily available on the VAN website (www.strokevan.com) which included Stroke VAN Training and the Full VAN Lecture.

From June 1, 2017 to December 31, 2019, all SAFD and AAS paramedics were required to perform a VAN assessment on all stroke alerts that were transported to any of the three CSCs. The RAC stroke alert criteria was defined as onset of symptoms within 6 hours, any abnormal finding on the CPSS, and blood glucose within 60–600 mg/dL. Thus, LKW 6–24 hours and wake-up strokes were excluded. Stroke alert criteria and results of prehospital CPSS and VAN assessments were extracted from the EMS electronic medical records. The three CSCs provided outcome data that included initial National Institutes of Health Stroke Scale (NIHSS) scores, advanced neuroimaging, MT if performed, and final diagnosis. NIHSS was determined on arrival at the CSC emergency departments and performed by either neurology residents, neurologists, emergency medicine

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physicians, or tele-neurologists. ELVO was determined by emergent advanced neuroimaging, generally CT angiography of the head, and included both anterior and posterior circulation intracranial occlusions. Specifically, ELVO was defined as thromboembolic occlusion of the intracranial internal carotid, middle cerebral (M1 or M2 segments), intracranial vertebral, or basilar arteries. The final diagnosis was recorded to assess for stroke subtypes and mimics. Mimics and intracranial hemorrhage (ICH) were included to represent real-world experience. Subjects were excluded from the final analysis if VAN or NIHSS was not available.

Analysis of data

The performance of VAN and NIHSS ≥6 for the presence of both ELVO alone and ELVO or any ICH combined were reported with positive predictive value (PPV), sensitivity, negative predictive value (NPV), specificity, and overall accuracy. MedCalc Software Ltd (Belgium) diagnostic test evaluation calculator was used for these measures and included output for 95% confidence intervals (CI). Descriptive statistics for continuous data were performed using Microsoft Excel (Version 16.36). χ^2 analyses for categorical data were performed using Social Science Statistics online calculator (www.socscostatistics.com). For subjects with intraparenchymal hemorrhage (IPH), volume was calculated based on the ABC/2 formula and the presence of intraventricular hemorrhage (IVH) was recorded.

RESULTS

Of the 386 stroke alert patients that were recorded, 290 (75%) had complete data and were included in the final analysis. Of these 290 subjects, the average age was approximately 59 years, VAN was positive in 193 (66.6%), NIHSS score was ≥6 in 168 (57.9%), and mean NIHSS score was 10. Final diagnoses included 76 non-ELVO stroke, 68 ELVO, 37 ICH, 28 transient ischemic attack, 23 seizures, 18 altered mental status, 9 migraine, 9 conversion, and 22 other (table 1). Of the 68 ELVO, 29 MTs (42.6%) were performed.

Both VAN and NIHSS ≥6 were significantly associated with ELVO alone and ELVO or any ICH combined using χ^2 analysis (table 2). However, when compared with VAN, NIHSS ≥6 demonstrated a greater association with both outcomes.

Overall, prehospital VAN trended towards a worse performance than hospital NIHSS ≥6 based on statistical measures (table 3). For ELVO alone and ELVO or any ICH combined, sensitivity and NPV were not significantly different between VAN and NIHSS ≥6. However, when comparing specificity and PPV, VAN signaled a non-significant trend of worse performance for ELVO alone and performed significantly worse for ELVO or any ICH combined. For both outcome measures, VAN showed a non-significant trend for worse accuracy compared with NIHSS ≥6.

The 37 subjects with ICH included 34 IPH, two subarachnoid hemorrhage, and one subdural hematoma. Of the 34 cases of IPH, mean±SD hemorrhage volumes were 2.5±4.0 mL for the five VAN-negative cases and 17.5±14.2 mL for the 29 VAN-positive cases. Additionally, any IVH was noted in 13 IPH subjects (39.4%), of which 11 (84.6%) were VAN-positive.

Table 1 VAN assessment by final diagnosis

Final diagnosis, n (%)	VAN +, n (%)	VAN –, n (%)
Non-ELVO stroke, 76 (26.2)	44 (57.9)	32 (42.1)
ELVO stroke, 68 (23.4)	55 (80.9)	13 (19.1)
ICH, 37 (12.8)	29 (78.4)	8 (21.6)
TIA, 28 (9.7)	11 (39.3)	17 (60.7)
Seizures, 23 (7.9)	16 (69.6)	7 (30.4)
Altered mental status, 18 (6.2)	12 (66.7)	6 (33.3)
Migraine, 9 (3.1)	4 (44.4)	5 (55.6)
Conversion, 9 (3.1)	6 (66.7)	3 (33.3)
Other, 22 (7.6)	13 (59.1)	9 (40.9)

ELVO, emergent large vessel occlusion; ICH, intracranial hemorrhage; TIA, transient ischemic attack; VAN, Vision, Aphasia, Neglect stroke assessment scale.

Table 2 χ^2 analysis for associations of ELVO alone and ELVO or any ICH combined with VAN and NIHSS ≥6

	VAN –	VAN +	NIHSS <6	NIHSS ≥6
ELVO –	84	138	112	110
ELVO +	13	55	10	58
χ^2 (p value)	8.2 (<0.01)		27.29 (<0.00001)	
ELVO or ICH –	79	106	107	78
ELVO or ICH +	18	87	15	90
χ^2 (p value)	19.66 (<0.00001)		52.13 (<0.00001)	

ELVO, emergent large vessel occlusion; ICH, intracranial hemorrhage; VAN, Vision, Aphasia, Neglect stroke assessment scale.

DISCUSSION

Compared with other prehospital EMS stroke severity tools, the prehospital VAN assessment in San Antonio, Texas showed better sensitivity (81%) but less specificity (38%) for ELVO. Recent prehospital stroke severity publications have reported sensitivity and specificity for RACE[19] (84% and 60%), C-STAT[20] (71% and 67%), and LAMS[21] (76% and 65%), respectively. These results suggest that assessments with more cortical measures, VAN and RACE, may exhibit greater sensitivity but less specificity than those with fewer or no cortical measures, C-STAT and LAMS. Although the original VAN publication reported 100% sensitivity and 90% specificity, it was studied as a hospital ED nurse triage and not a prehospital EMS tool.[15] Thus, performance measures from the original VAN publication have limited application when comparing with our prehospital VAN results.

Cortical signs such as eye deviation, aphasia, and neglect are highly sensitive for ELVO but also associated with stroke mimics, including ICH, migraine, seizure, and altered mental status. Thus, VAN may result in decreased specificity due to its dichotomized design and inclusion of all three major cortical signs (vision, aphasia, and neglect) but only one motor assessment (arm). Although RACE also incorporates all three major cortical signs, it has a categorical design and includes three motor measures (face, arm, and leg). Similar to VAN, C-STAT incorporates a single motor assessment (arm) but is categorical and includes only two cortical signs (gaze and aphasia). LAMS is a categorical motor scale without cortical signs. The decreased specificity of assessments with more cortical features may be overcome by including additional motor assessments as well as a greater emphasis on continuous EMS education. The distinction between dysarthria and aphasia, as well as the recognition of neglect, requires a more in-depth understanding of the neurological examination. Although VAN training for paramedics was performed prior to our study initiation, continuing education throughout the study was not mandatory and variably distributed.

The optimal prehospital stroke severity scale remains unclear because none predict ELVO with both high sensitivity and

Table 3 Statistical measures of VAN and NIHSS ≥6 for the presence of ELVO alone and ELVO or any ICH combined

	ELVO				ELVO or any ICH			
	VAN		NIHSS ≥6		VAN		NIHSS ≥6	
Outcome	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Sensitivity	80.9	69.5 to 89.4	85.3	74.6 to 92.7	82.9	74.3 to 89.5	85.7	77.5 to 91.8
Specificity	37.8	31.4 to 44.6	50.5	43.7 to 57.2	42.7	35.5 to 50.2	57.8	50.4 to 65.1
PPV	28.5	25.5 to 31.8	34.5	30.9 to 38.4	45.1	41.4 to 48.9	53.6	48.9 to 58.2
NPV	86.6	79.4 to 91.6	91.8	86.2 to 95.3	81.4	73.6 to 87.3	87.7	81.5 to 92.1
Accuracy	47.9	42.1 to 53.9	58.6	52.7 to 64.4	57.2	51.3 to 63.0	67.9	62.2 to 73.3

ELVO, emergent large vessel occlusion; ICH, intracranial hemorrhage; NIHSS, National Institutes of Health Stroke Scale; NPV, negative predictive value; PPV, positive predictive value; VAN, Vision, Aphasia, Neglect stroke assessment scale.

specificity.[22] Thus, selection of a prehospital assessment should consider the goals and resources of regional stroke systems of care. Because our ELVO bypass algorithm is limited to within 6 hours of LKW, we favor VAN for its high sensitivity and simplicity to learn and teach. On the other hand, stroke systems of care that incorporate a 0–24 hour ELVO algorithm will bypass more subjects and may favor a prehospital assessment with greater specificity and possibly fewer cortical signs. Although we believe VAN would perform similarly in the extended 6–24 hour window, these subjects were not included in our study. Prehospital assessments with high specificity will minimize unnecessary bypass due to stroke mimics, avoid overwhelming MT centers, and optimize current hub and spoke networks.

ICH was included in our analysis to represent real-world experience as many require neurosurgery evaluation or CSC transfer. VAN specificity and sensitivity improved when the outcome included ELVO or any ICH, compared with ELVO alone. Furthermore, VAN-positive ICH subjects had larger hemorrhage volumes. Our findings not only support prior results of VAN screening to identify high-risk ICH,[23] but also the use of VAN as an effective prehospital ICH bypass tool.

Our study is limited by the exclusion of stroke alerts that did not have a documented VAN or NIHSS score on arrival at the CSC. These excluded subjects often had final diagnoses of stroke mimics or ICH and thus may have overestimated VAN performance. On the other hand, VAN performance may have been underestimated due to ELVO recanalization by spontaneous lysis or IVT prior to completion of vascular imaging. Because the prehospital assessment has a greater time interval to vascular imaging, a VAN-positive patient may have spontaneous ELVO recanalization in the field that results in a hospital NIHSS <6 and unremarkable vascular imaging. Similarly, a VAN-positive patient with seizure may have resolution of clinical symptoms in the field that also results in a hospital NIHSS <6. By design, prehospital assessments, including VAN, are performed early in the stroke triage and may demonstrate decreased specificity compared with hospital NIHSS. Despite our cohort having a relatively young average age of 59 years, a notable strength of our study design is applicability based on the inclusion of two EMS agencies and three CSCs.

CONCLUSIONS

The ideal prehospital stroke severity scale and bypass time window protocol remain undetermined. Our VAN study adds to the published evidence that prehospital EMS assessments can be effectively taught and implemented in stroke systems with multiple EMS agencies and CSCs. Because regional stroke systems of care are uniquely designed, ELVO prehospital assessments and bypass time windows are variable and should be determined by collaborative groups that consider their geographic distribution of stroke resources.

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Data availability statement Data are available upon reasonable request. The data is deidentified, retrospective from stroke alert patients in San Antonio, Texas. Reuse is permitted upon a reasonable request.

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