Design, Application and Infield Validation of a Pre-Hospital Emergent Large Vessel Occlusion Screening Tool: Ventura Emergent Large Vessel Occlusion Score

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Background: The outcome of endovascular treatment for emergent large vessel occlusion (ELVO) is dependent on timely recanalization. To identify ELVO in the field, we present a simplified score, which has been applied and validated in the field by emergency medical services (EMS). *Methods and Analysis:* Ventura ELVO Scale (VES) comprise of 4 components: Eye Deviation, Aphasia, Neglect, and Obtundation with score range 0-4. The score of greater than or equal to 1 will be considered as ELVO positive. A positive VES along with positive Cincinnati scale prompts ELVO activation. EMS then notify to neurointervention protocol at the receiving stroke center. The performance of VES was evaluated retrospectively. For statistical analysis, SAS version 9.4 was used and Fisher's modelling was used for the comparative analysis. *Results:* Total 184 patients were included in the final analysis, 62 (33.7%) patients were called VES positive from the field. Out of 62, 36 (58%) patients had ELVO. The mean NIHSS on arrival was 16 in VES positive and 5 in VES negative patients. VES was 94.7% sensitive and 82.4% specific while the PPV and NPV of VES were 58.1% and 98.4%, respectively. It showed 84.9% accuracy. *Conclusions:* VES is an effective and simplified prehospital screening tool for detection of ELVO in the field. Its implementation can beat the target door to groin time to improve outcomes and in future it can be used for rerouting of ELVO patients to comprehensive stroke center.

Key Words: Acute ischemic stroke—emergent large vessel occlusion (ELVO)—endovascular treatment (EVT)—pre-hospital screening tool

Background and Introduction

Endovascular treatment (EVT) with mechanical thrombectomy has been established as the first-line therapy for patients with acute ischemic stroke from emergent large vessel occlusion (ELVO).[1-6] The clinical outcome, however, is dependent on timely recanalization of intracranial blood vessels.[7-9] Patients who arrive at the emergency department (ED) within 3 hours of the onset of their first symptoms tend to have better outcomes at 3 months after a stroke than do those who receive delayed care.[10] Therefore, it is vital that signs and symptoms of stroke are recognized as early as possible. Although EVT confers the benefit of a longer time window, up to 24 hours, the chances of a good outcome are still time-dependent.[6,11-13]

Acknowledging the time-critical nature of ELVO treatment, effective and efficient prehospital triage of patients with ELVO has become the focus for stroke care

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revolution. In order to achieve efficient prehospital care, the American Heart Association recommends the inclusion of assessment tools to identify stroke in the field and early notification of receiving stroke centers by emergency medical services (EMS).[14] Although the National Institutes of Health Stroke Scale (NIHSS) is the mostly commonly used tool for the assessment of stroke and ELVO by physicians and nurses, it is probably a time-consuming task for EMS to perform.[15] A shortened version of the NIHSS was proposed; unfortunately, this version was also relatively unwieldy in a prehospital setting where timely transfer to a specialized center is a priority.[16] Therefore, several prehospital in-field stroke assessment tools, such as the Los Angeles Motor Scale (LAMS), Rapid Arterial oCclusion Evaluation Scale (RACE), vision, aphasia, and neglect (VAN), 3-item stroke scale (3I-SS), FAST-ED, C-STAT, and severe hemiparesis, have been put forth to specifically screen for ELVO.[17-22] These tools have yet to be been validated, in the prehospital setting and have limitations.

The Ventura ELVO Score (VES) is a simplified scoring system to identify ELVO. It was incorporated in the prehospital assessment by EMS in Ventura County. We evaluated its feasibility and accuracy to identify ELVO in the field.

Methods

Design and Score Components

The VES was constructed by incorporating the 3 cortical signs (aphasia, neglect, and eye deviation) as the examination components of the score. We also included obtundation as one of the components to identify posterior circulation strokes. Basilar artery occlusion is expected to impair the consciousness of patients. In order to keep it simple and easy for administration by EMS, the components were not stratified. Instead, the results were kept categorical as positive or negative. The scoring system may help to increase the specificity of the scale in future. The VES score ranges from 0 to 4. If either component is positive (score of 1), the VES is also considered positive **(**Table 1**)**.

In-Field Training and Implementation

As a process improvement procedure, VES was designed in collaboration with Ventura County EMS to identify strokes with ELVO in the field. Since its implementation, VES has been used in conjunction with the Cincinnati Pre-hospital Stroke Scale (CPSS) by paramedics to identify a Code Stroke with ELVO. Paramedics screen patients suspicious for stroke with CPSS. If patients are CPSS-positive, then they are assessed using the VES. If the patient is determined to be ELVO-positive, they are activated as code stroke ELVO from the field. The receiving hospital is notified. The interventional neurologist then activates the Interventional Radiology team. With this approach, the neurointerventionalist and the Interventional Radiology team are ready for possible EVT if ELVO is evident on initial imaging studies combined with neurological assessment by the interventional neurologist. The results of CPSS and VES assessment are recorded on EMS run sheets by EMS personnel.

Before the implementation of VES assessment in the field, a collaboration was established with Ventura county emergency medical service, (VCEMS) after discussing its feasibility and quality assurance. A series of training sessions were held by the author to demonstrate to EMS personnel how to perform VES assessment with CPSS. They were also shown a simulated video to demonstrate how to perform and what signs to look for **(Supplementary Video 1).** In these training sessions, EMS personnel were also educated about the importance of rapid transfer of ongoing ELVOs, so that these patients could receive EVT as early as possible. To ensure continuous education and to monitor implementation, several follow-up sessions were held with EMS personnel.

Retrospective Data Collection

The performance of VES was evaluated retrospectively by collecting unidentified data. This retrospective study was submitted to the Western Institutional Review Board and was granted an exemption from a full board review under 45 CFR 46.101(b)(4). For data collection, the electronic medical charts from Los Robles Hospital and Medical Center and Ventura County EMS run sheets from Jan 1, 2016 to Apr 25, 2017 were used as sources. All patients were greater than or equal to 18 years of age, were assessed in the field for stroke by EMS, and were brought to the receiving hospital as code stroke by EMS. We excluded those stroke codes who were transferred from outside hospitals. The patients whose charts were not available were also excluded from the final data analysis.

In addition to the results of CPSS and VES assessments, the key time points, including last-known well (LKW) time, ED arrival time, and initial imaging time, were collected in an unidentified fashion. We also collected initial NIHSS score, preferably done by a neurologist (if not available, then performed by ED physician). A computerized tomography scan was done in every patient who presented as code stroke. In most of the cases, computerized tomography angiogram was used in addition to computerized tomography scan to determine the presence or absence of ELVO. Based on findings from imaging and neurological assessment, diagnosis of EVT was made.

Statistical Analysis

For statistical analysis, SAS version 9.4 software was used. We calculated the count and proportion of the VES positive and VES negative stroke codes. We also calculated the proportions of stroke codes based on

Table 1. *Ventura ELVO score (VES)*

VES components	Score
(1) *Eye deviation* - Forced deviation of BOTH eyes to either side.	☐ Positive = 1 ☐ Negative = 0
(2) *Aphasia* - Patient is awake but one or more of the following is present: - Unable to repeat a sentence. - Unable to name an object. - Talking gibberish and/or not following any commands. - Mute	☐ Positive = 1 ☐ Negative = 0
(3) *Neglect* - Identified by individual then simultaneous stimulus. (If patient can feel both sides individually but not feeling one side on simultaneous stimulation then its positive)	☐ Positive = 1 ☐ Negative = 0
(4) *Obtundation* - Positive if patient is not staying awake during conversation.	☐ Positive = 1 ☐ Negative = 0

Notes: Maximum 4 and Minimum 0. Score of 1 or greater is considered as ELVO Positive.
- If Aphasia positive then neglect can be evaluated by noticing if patient is not paying attention to you when you stand on one side but pay attention to you when you stand on the other side.

their diagnosis with respect to VES score. All stroke codes were divided into 4 categories: ischemia with ELVO, ischemia without ELVO, hemorrhagic stroke, and others mimicking stroke (eg, seizures, encephalopathy, etc.) The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were calculated for VES.

Results

Based on our inclusion criteria, we found 194 patients who were activated as code stroke from the field by VCEMS, out of which 65 stroke codes were brought in as VES-positive. Eight patients were not included in the analysis due to unavailability of charts for retrospective review. Therefore, 186 patients with VES evaluation in the field were included in the final analysis. Sixty-two of these 186 patients were called VES-positive in the field, with mean NIHSS of 16 on ED arrival. The mean NIHSS of the 124 patients who were called VES-negative in the field was 5. Thirty-eight patients had confirmed diagnosis of ELVO. The number of patients with site of proximal occlusion in CCA was 1, in Internal carotid artery (ICA) was 11, in Middle cerebral artery (MCA) was 25, and in Anterior cerebral artery (ACA) was 1. The median VES scores for each site of occlusion were 2, 2, 1, and 3, respectively.

In the VES-positive subgroup of patients, 36 (58%) had ELVO, 17 (27%) had ischemia without ELVO, 8 (13%) had hemorrhage, and 1 (<1%) had another diagnosis with simulated presentation. In the VES-negative subgroup of patients, 2 (<1%) had ELVO (Fig. 1 & 2).

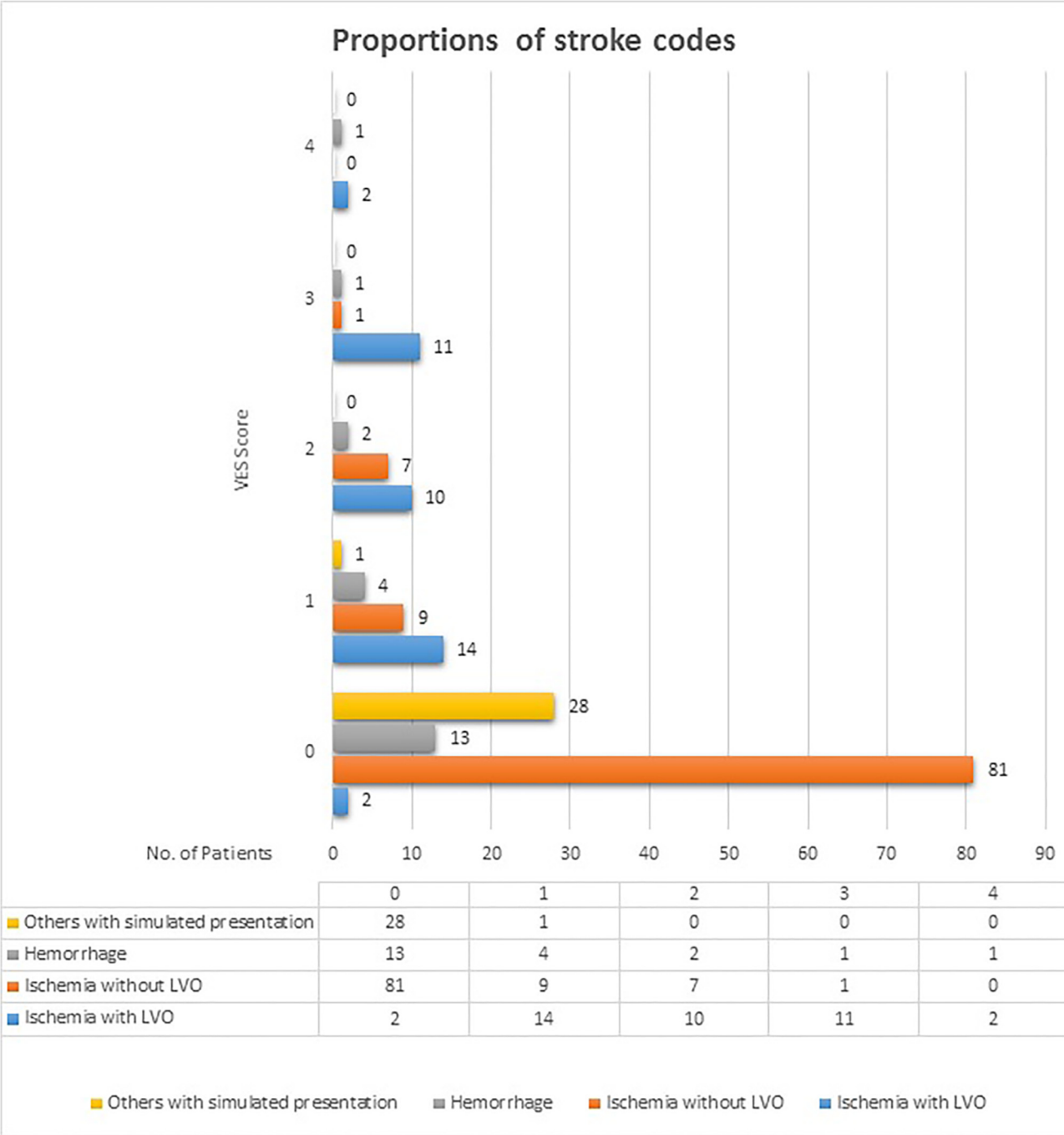
The VES was 94.7% sensitive and 82.4% specific, whereas the positive predictive value and negative predictive value of the VES were 58.1% and 98.4%, respectively. The accuracy of VES was 84.9%.

Discussion

The importance of timing is undeniable in the management of acute ischemic stroke and subsequent patient outcomes. According to the Diffusion and Perfusion Imaging Evaluation for Understanding Stroke Evolution (DEFUSE)-3 trial, mechanical thrombectomy has shown better functional outcome up to 16 hours from LKW in patients with ischemic stroke with favorable findings on perfusion imaging.[13] The DWI or CTP Assessment with Clinical Mismatch in the Triage of Wake-Up and Late Presenting Strokes Undergoing Neurointervention with Trevo (DAWN) trial showed better outcomes with thrombectomy in patients with a mismatch between severity of clinical deficits and infarct volume up to 24 hours from LKW.[12] However, any reperfusion therapy has maximum benefit when offered in the shortest period from onset of symptoms.[10] It is vital to recognize signs of large vessel occlusion as early as possible not only for early intervention but also to help triage patients in the field.

Our study demonstrated that the VES is a simplified tool for EMS personnel to identify acute stroke with ELVO. Our findings showed that the VES is highly effective screening tool with high sensitivity (94.7%) and specificity (86.8%). It is also reliable, with a high positive predictive value of 58.1%. The VES showed high accuracy (84.9%) as well.

Although several screening tools for ELVO are reported in the literature, they have limitations. The 3I-SS has been criticized as it was not derived from the NIHSS. Although



	0	1	2	3	4
Others with simulated presentation	28	1	0	0	0
Hemorrhage	13	4	2	1	1
Ischemia without LVO	81	9	7	1	0
Ischemia with LVO	2	14	10	11	2

Figure 1. *Number of patients with ischemia with ELVO, ischemia without ELVO, hemorrhage and others with simulated presentation for each VES score component. Abbreviations: ELVO, emergent large vessel occlusion; VES, ventura emergent large vessel occlusion score.*

the LAMS is much easier to employ and is being used in the field, it does not assess the cortical deficits that are more predictive of an ELVO. The LAMS makes use of a more simplified approach, but it has shown low sensitivity and specificity of 81% and 89%, respectively, at the optimal threshold of greater than or equal to 4.[17]

The RACE scoring system is another screening tool, introduced and validated by Lima et al in 2013.[19] It is derived from the predictive components from the NIHSS (facial palsy, arm motor function, leg motor function, gaze, and aphasia or agnosia) to provide a simpler alternative to NIHSS for EMS.[19] The score is not user-friendly for administration in the field.[19] In order to overcome this shortcoming, modifications of the RACE scale were attempted, but these efforts resulted in lower predictive values. At the threshold of greater than or equal to 5, the

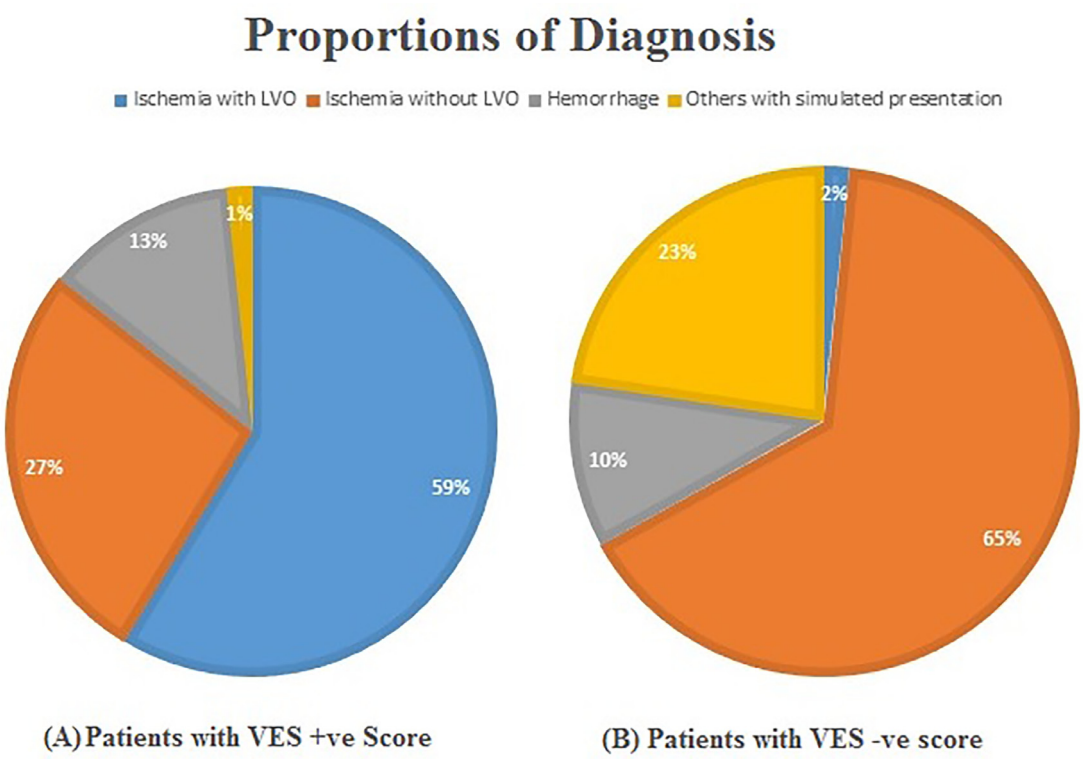


Figure 2. *Proportions of diagnosis in patients (A) positive VES score (B) negative VES score. Abbreviation: VES, ventura emergent large vessel occlusion score.*

RACE scale showed sensitivity and specificity of 85% and 68%, respectively.[19] Another attempt to design a screening tool was made in 2016 by Lima et al, who introduced the FAST-ED pre-hospital scale.[21] Similarly, this tool was derived from the predictive components of NIHSS. It showed sensitivity of 61% and specificity of 89% at the threshold score of 4.[21] It is yet to be validated in the field.

Recently, a simple screening tool to identify ELVO, called VAN, was introduced by Teleb et al. This screening tool tests more cortical functions than both the 3I-SS and LAMS. VAN has been tested in the ER by nurses, but it is yet to be validated in the field. In a small pilot study of 62 stroke codes, VAN captured all patients that were considered for thrombectomy (100% sensitivity). Only 5 VAN-positive patients were found to have no large vessel occlusion (90% specificity), out of which 4 were stroke mimics. In addition to not being applied in the field, the major limitation of this study was the very small cohort of patients. Therefore, the results of the VAN study may not be a reliable estimation of its accuracy and warrant a study with a larger cohort and outside of the ER.

We demonstrated that VES can be taught to the EMS personnel in the field and can be employed with ease. EMS personnel in Ventura County found the VES to be less time-consuming and easy to remember to apply for the assessment of ELVO. Because of its nonstratified examination components, no complicated calculations are required. A score of 1 or more leads to the activation of code ELVO, and early notification of interventional neurologist for activation of stroke code process. Another notable aspect of our study was that the VES showed better results than did the NIHSS threshold of greater than or equal to6 based on reported sensitivity and specificity of NIHSS. This threshold was recommended by the 2015 American Heart Association update as a criterion for EVT.[2]

Based on our experience and results, the VES score can be used in the field by EMS for the prenotification and activation of code stroke and ELVO. With early notification by EMS from the field, door-to-imaging time can be reduced. Early notification of an ELVO can also play a pivotal role to reduce door-to-needle time for intravenous tissue plasminogen activator and door-to-groin-puncture time for EVT.

Study Limitations and Strengths

The major limitations of our study included that it was conducted at single center, and only included those patients who were activated as stroke codes by EMS of Ventura County. Those stroke codes who were brought to our stroke center by EMS of other counties were excluded, since we lacked collaboration with other EMS agencies. The neurologist who performed the NIHSS assessment was at a different time than VES; VES was performed in the field while NIHSSS was performed in the hospital. Therefore, the comparison between the two, cannot be

very accurate since some of the patient may had improvement or worsening of their deficits on arrival to ED.

The significant strength of our paper is the infield application of the score by the EMS. The results of this study can be applied in a future multicenter study with a larger cohort to further validate the results. In the modern era of mechanical thrombectomy for LVO, the center of growing focus in the interventional community is the earliest intervention and reperfusion. A prehospital scale like this can also help triage patient to Comprehensive or Thrombectomy centers and by-passing the primary stroke center.

Conclusions

The VES is an effective prehospital screening tool for ELVO when it is coadministered with CPSS. It is a simple tool with nonstratified examination components, so that it can be easily and quickly assessed by EMS technicians in the field. The results indicated that the VES accurately identified in the field those stroke codes who might have ELVO. Its implementation can improve the target door-to-needle and door-to-groin puncture time for revascularization. In the future, this screening tool may play a major role in the triage of stroke codes and rerouting patients to a comprehensive stroke center for possible EVT.

Contributorship

M.A. Taqi: Designed screening tool and research study, contributed in manuscript writing, critical review, edition and approval of paper.

A. Sodhi: Contributed in data collection; critical review, edition and approval of paper.

S.S. Suriya: Contributed in the data collection; manuscript writing, edition and approval of paper; helped in statistical analysis.

S.A. Quadri: Contributed in the data collection; manuscript writing, edition and approval of paper; helped in statistical analysis.

M. Farooqui: Statistical analysis; critical review and approval of paper.

A.A. Salvucci: Screening tool implementation; critical review, edition and approval of paper.

A. Stefansen: Screening tool implementation; contributed in data collection; critical review and approval of paper.

M.M. Mortazavi: Critical review, edition and approval of paper.

D. Shepherd: Screening tool implementation; critical review, edition and approval of paper.

Data Sharing

N/A.

Ethics Approval

This study was granted an exemption from a full board review under 45 CFR 46.101(b) (4).

Supplementary materials

Supplementary data to this article can be found online at doi:10.1016/j.jstrokecerebrovasdis.2018.11.014.

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