Vision, Aphasia, Neglect Assessment to Predict Neurosurgical Intervention in Patients with Nontraumatic Intracerebral Hemorrhage

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Background and Purpose: The Vision, Aphasia, and Neglect (VAN) screening tool is a simple bedside test developed to identify patients with large vessel occlusion stroke. In the setting of intracerebral hemorrhage (ICH), there are very few bedside predictors of need for neurosurgical interventions other than age and Glasgow Coma Scale (GCS). We aimed to assess the utility of the VAN screening tool in predicting the need for neurosurgical intervention in patients with ICH. *Methods:* We accessed sensitivity, specificity, positive predictive value, negative predictive value (NPV), and area under receiver operating characteristics curve of VAN for identifying ICH patients who require neurosurgical intervention. *Results:* Among 228 ICH patients, 176 were VAN positive and 52 were VAN negative. On unadjusted analyses, VAN positive patients had a significantly higher ICH volume, GCS score, and National Institutes of Health Stroke Scale score ($P < .001$ for all). As compared to VAN negative patients, significantly higher proportion of VAN positive ICH patients (15.4% versus 32.4%) underwent a neurosurgical procedure such as external ventricular drain (EVD) and/or hematoma evacuation with craniotomy or craniectomy. The VAN screening tool had high sensitivity and NPV (100%) in predicting the need for craniectomy or hematoma evacuation, but had lower sensitivity (87.7%) for any neurosurgical procedure, as 15.4% of VAN negative patients received EVD. *Conclusions:* Our study suggests that VAN screening tool can identify high-risk ICH patients who are more likely to undergo craniotomy or craniectomy but is less sensitive to rule out need for EVD.

Key Words: VAN scale—intracerebral hemorrhage—prehospital screen—prehospital stroke

Introduction

Intracerebral Hemorrhage (ICH) accounts for approximately 10% to 15% of all strokes and carries high mortality and severe long-term disability rates.[1] Treatment goals in ICH include reduction in hematoma expansion and secondary brain injury, but approximately 20% of patients have hematoma expansion leading to neurological deterioration and a reduction in survival.[2] Neurosurgical interventions such as external ventricular drain (EVD) and craniotomy are indicated to emergently ameliorate herniation and death. Neurosurgeons provide immediate or inhouse 24-hour coverage in hospitals designated as Trauma or Stroke Centers, but those centers only account for about 45 percent of the nation's hospitals.[3]

Patients presenting to hospitals without neurosurgical coverage are often transferred many miles to be treated by

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a neurosurgeon. A clinical tool that identifies patients more likely to require craniotomy would allow those patients to be triaged to more advanced centers. An optimal bedside tool could be used in the prehospital setting to predict which stroke patients (both ischemic or ICH) would benefit from triage to a hospital with neurosurgical and endovascular stroke capabilities. The vision, aphasia, neglect (VAN) assessment was first introduced to predict large vessel occlusions (LVOs) in the prehospital setting for triage to appropriate facility.[4] We hypothesized that the VAN assessment could also be used to predict which patients with ICH will need neurosurgical intervention.

Methods

Study Population

We analyzed prospectively collected dataset for all nontraumatic ICH patients that were admitted through the emergency department from year 7/2008 to 12/2016. Inclusion criteria were age more than 18 years with nontraumatic ICH, presentation within 24 hours from last seen normal, and complete National Institute of Health Stroke Scale (NIHSS) exam documented on arrival. Patients were included if data was available on Glasgow Coma Scale (GCS), ICH volume, presence of intraventricular hemorrhage (IVH), neurosurgical intervention, length of stay, and modified Rankin Score on discharge. ICH volumes were calculated based on ABC/2 formula.[5]

Outcome

Patients undergoing any type of neurosurgical procedure were considered to have the outcomes of interest. These included neurosurgical decompression, hematoma evacuation, neurosurgical ventriculostomy, placement of EVD, and neurosurgical monitoring of intracerebral pressure. Two categories of interventions (EVD and all other neurosurgical procedures) were defined for analyses.

VAN Determination

First documented NIHSS was used to extrapolate VAN score. VAN starts with testing arm weakness. If arm weakness (mild-minor drift, moderate-severe drift-touches or nearly touches ground or severe-flaccid or no antigravity) is present, examination proceeds to detection of vision disturbance (field cut, or double vision, or blind-new onset, or none), aphasia (expressive, or receptive, or mixed, or none), or neglect (forced gaze or inability to track to one side, or unable to feel both sides at the same time, or unable to identify own arm, or ignoring one side, or none). If no arm weakness is present, patient is deemed VAN negative thus halting further testing. VAN is scored positive when arm weakness is present with any one or more positive cortical signs (VAN).[4]

Statistical Methods

We performed univariable comparison of demographic and clinical variables for VAN positive and negative ICH patients. Summary statistics are provided as means (standard deviations), medians (interquartile range—IQR), and frequencies. Univariable logistic regression models were fitted to assess the likelihood of association of these variables with a VAN positive screening among ICH patients. Odds ratios (OR), 95% confidence intervals (CI) and *P* valued obtained from Wald test are reported. We further fit a multivariable model to assess the independent association between neurosurgical procedures and positive VAN. Sensitivity, specificity, positive predictive value, negative predictive value of VAN was calculated to estimate the predictive value for neurosurgical intervention including EVD with or without clot evacuation and craniectomies. Concordance statistic (c-statistic) was calculated by area under the receiver operating curve (AUC) to measure the accuracy of predicting neurosurgical procedure with the following scale performance .9-1 excellent, .8-9 good, .7-8 fair, .6-7 poor and .5-6 fail. As has been reported by other studies, accuracy was calculated based on the proportion of patients correctly classified (either as true positive or true negative) from among the total ICH patients.[6] Tulane University School of Medicine IRB approved this study.

Results

The Stroke Registry identified 371 patients with spontaneous nontraumatic ICH. Of these, 260 patients presented within 24 hours from last seen normal. A total 228 patients qualified for this study due to complete NIHSS documentation. The mean (standard deviations) age for the entire group was 63.0 (15.4) years, 68.9% were black (African American) and 49.1% were female. Of the 228 patients, 176 (77%) were VAN positive and 52 (23%) were VAN negative. A greater proportion of African American ICH patients were VAN positive as compared to White patients (73.9% versus 51.9%; *P* = .003; OR, 95% CI: 2.72, 1.39-5.61). Furthermore, median (IQR) GCS was significantly lower in VAN positive patients (median 11; IQR 7-15) as compared to VAN negative patients (median 15: IQR 15-15), and median ICH volume was significantly larger (19 cc; IQR 7-51 versus 1 cc; IQR 1-7). A significantly greater proportion (50.0%) of VAN positive patients had IVH as compared to VAN negative patient (30.8%). Univariable comparison for VAN positive and VAN negative ICH patients for various demographic and clinical factors are summarized in Table 1. In the unadjusted analyses, a significantly higher proportion of VAN positive patients underwent any kind of neurosurgical procedure (EVD with or without clot evaluation, craniectomy) (32 % versus 15%; *P* = .02; OR, 95% CI: 2.63, 1.16-5.96). This association remained statistically significant even after adjusting for race in the multivariable model

Table 1. *Baseline characteristics*

	Total (n = 228)	VAN + (n = 176)	VAN − (n = 52)	*P* value	OR (95% CI)
Age, mean (SD)	63.0 (15.4)	62.8 (15.9)	63.7 (13.5)	.71	.99 (.97-1.02)
Race					
White (%)	26.8	22.2	42.3	Reference	
Black (%)	68.9	73.9	51.9	.003	2.72 (1.39-5.29)
Hispanic, Asian and others (%)	4.4	4.0	5.8	.71	1.32 (.31-5.61)
Gender (Female) %	49.1	49.4	48.1	.86	1.05 (.57-1.96)
GCS: median (IQR)	13.5 (8-15)	11 (7-15)	15 (15-15)	<.001	.57 (.45-.74)
NIHSS: median (IQR)	16 (8-25)	19 (12.5-27)	4 (1.5-6)	<.001	1.33 (1.22-1.44)
ICH Volume: median (IQR)*	13 (3.4-40)	19 (7-51)	1 (1-7)	<.001	1.08 (1.04-1.13)
Baseline IVH (%)	45.6	50.0	30.8	.01	2.3 (1.16-4.35)
Any NS procedure (%)	28.5	32.4	15.4	.02	2.63 (1.16-5.96)
NS excl. EVD (%)	10.5	13.6	.0	-	-
mRS on discharge: median (IQR)	4 (4-6)	5 (4-6)	3 (2-4)	<.001	2.41 (1.83-3.16)
Length of stay: median (IQR)	7 (4-16.5)	8 (4-19.5)	5 (3-10)	.01	1.05 (1.01-1.09)

Abbreviations: CI, confidence intervals; EVD, external ventricular drain; GSS, Glasgow Coma Scale; ICH, intracerebral hemorrhage; IQR, interquartile range; IVH, intraventricular hemorrhage; mRS, modified Rankin Score; NIHSS, National Institute of Health Stroke Scale; NS, Neurosurgery; OR, odds ratios; SD, standard deviations; VAN, vision, aphasia, and neglect.

*n = 201.

(OR, 95% CI: 2.46, 1.08-5.64). We did not include NIHSS or GCS in the multivariable due to high collinearity and derivation of VAN directly from the NIHSS. No patients who were VAN negative underwent any kind of neurosurgical procedure other than EVD.

VAN had 100% sensitivity in identifying patients who would need neurosurgical procedures like clot evacuation and/or craniectomy and 100% negative predictive value. However, VAN had low accuracy (33%-44%) and is poor test in predicting neurosurgical procedures based on c-statistic (.57-.63) (Table 2).

Discussion

We were successfully able to demonstrate utility of VAN in predicting the need for neurosurgical intervention in the setting of ICH using a large hospital dataset. VAN is the first prehospital screening test used to predict such high-risk ICH patients.

VAN positive patients had higher odds of having large ICH volumes, IVH and significantly lower GCS all of which are independently associated with 30-day mortality based on ICH score.[7]

VAN scale is unique as it incorporates the cortical structures that affect vision, aphasia and neglect thus if positive, indicating that the stroke is large enough to involve cortical structures. Advantages of VAN include an easy to administer test guided by the pneumonic VAN with no score calculation required. The results of VAN test is either positive or negative which one can ascertain as the test is progressing. In the first VAN study, emergency room nurses were trained to administer VAN test in a 2-hour training session after which nurses were able to administer the exam in 15 seconds and had an interobserver reliability of 100% (nurses and physicians).[4]

High sensitivity (88%-100%) of VAN in predicting any neurosurgical procedure means VAN positive patients should be transported to a hospital with neurosurgical availability. VAN also had a high negative predictive value (85%-100%), which means VAN negative patients could be diverted to the nearest hospital for stability and to establish final diagnosis without diversion to higher level of care. In our dataset, 15% patients in the VAN

Table 2. *VAN test utility*

Score	Sensitivity	Specificity	PPV	NPV	Correctly classified*	C-statistic
NS procedure % (95% CI)	87.69 (77.18-94.5)	26.99 (20.4-34.5)	32.39 (25.5-39.8)	84.62 (71.9-93.1)	44.3	.57 (.52-.63)
NS procedure Excl. EVD % (95% CI)	100.00 (85.8-100.0)	25.49 (19.7-32.1)	13.64 (9.0-19.6)	100.00 (93.2-100.0)	33.3	.63 (.60-.66)

Abbreviations: CI, confidence intervals; EVD, external ventricular drain; NPV, negative predictive value; PPV, positive predictive value; VAN, vision, aphasia, and neglect.

*([True positives + true negatives]/total number of patients).

negative group required neurosurgical intervention that were limited to EVDs. This could have been due expected hematoma expansion and neurological deterioration in ICH patients. None of the patients in the VAN negative group required craniectomy or hematoma evacuation thus these patients could be secondarily transferred to higher level of care once diagnosis is established. Although craniotomies are exclusively performed by neurosurgeons, EVD can be performed by other physicians or even trained midlevel practitioners,[8] potentially allowing lower risk patients to be cared for at less comprehensive centers followed by transfer, if needed.

We anticipate that the faster the high-risk VAN positive patients are transported to comprehensive level of care, the higher the chances of survival and perhaps lesser disability, which of course remains to be proven.

Unlike Japan Urgent Stroke Triage score [9] that distinguishes between different stroke subtypes in prehospital setting, VAN identifies large strokes that need intervention either LVO or high-risk ICH patients requiring neurosurgical intervention. No other prehospital LVO screening test has utilized applicability of these scales in predicating triage for ICH patients thus we could not compare VAN with any other scales. A Los Angeles Motor Scale score greater than or equal to 4 has been shown to have high sensitivity and specificity in identifying Comprehensive Stroke Center appropriate patients, however it does not actually predict the need for neurosurgical procedures.[10]

Shortcomings of our study are that it is a single center study but from a high-volume stroke center utilizing emergency department and inpatient dataset. Generalizability of this test in the prehospital setting remains unproven. Our sample size was likely limited, as sicker ICH patients could have been admitted to neurosurgical service with no NIHSS documentation on admission. Even though the accuracy and AUC were poor for VAN in the study, the high sensitivity, and negative predictive value can be still be utilized to triage patients. Another limitation is lack of data on the timing of the neurosurgical intervention so we could not determine that identification of potential neurosurgical candidates using VAN provided an advantage in early intervention.

Conclusion

VAN screening test can be utilized to triage ICH patients. A prospective study is required to validate our findings when performed in the prehospital setting.

Disclosures

None.

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