Detailed severity assessment of Cincinnati Prehospital Stroke Scale to detect large vessel occlusion in acute ischemic stroke

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Abstract

Background

Selecting stroke patients with large vessel occlusion (LVO) based on prehospital stroke scales could provide a faster triage and transportation to a comprehensive stroke centre resulting a favourable outcome. We aimed here to explore the detailed severity assessment of Cincinnati Prehospital Stroke Scale (CPSS) to improve its ability to detect LVO in acute ischemic stroke (AIS) patients.

Methods

A cross-sectional analysis was performed in a prospectively collected registry of consecutive patients with first ever AIS admitted within 6 hours after symptom onset. On admission stroke severity was assessed National Institutes of Health Stroke Scale (NIHSS) and the presence of LVO was confirmed by computed tomography angiography (CTA) as an endpoint. A detailed version of CPSS (d-CPSS) was designed based on the severity assessment of CPSS items derived from NIHSS. The ability of this scale to confirm an LVO was compared to CPSS and NIHSS respectively.

Results

Using a ROC analysis, the AUC value of d-CPSS was significantly higher compared to the AUC value of CPSS itself (0.788 vs. 0.633, $p < 0.001$) and very similar to the AUC of NIHSS (0.795, $p = 0.510$). An optimal cut-off score was found as d-CPSS ≥ 5 to discriminate the presence of LVO (sensitivity: 69.9%, specificity: 75.2%).

Conclusion

A detailed severity assessment of CPSS items (upper extremity weakness, facial palsy and speech disturbance) could significantly increase the ability of CPSS to discriminate the presence of LVO in AIS patients.

Background

Endovascular thrombectomy (EVT) is effective to treat patients with acute ischemic stroke (AIS) caused by large vessel occlusion (LVO), which occurs in 20–40% of cases [1, 2]. There is a growing need for simple diagnostic methods that can detect these patients early on. A reliable LVO detection tool could be useful for emergency medical services (EMS) to select patients with a high likelihood of LVO, as these patients may benefit from a direct transportation to an EVT capable comprehensive stroke centre (CSC) [3].

Cincinnati Prehospital Stroke Scale (CPSS) is a simple, three item scale, widely used by EMS. It is easy and quick to learn or perform and has good ability to identify potential stroke patients. Nonetheless, it only has moderate ability to detect AIS patients with LVO, however, important aspect is that CPSS only tests for the presence of three symptoms (facial palsy, upper extremity weakness and speech disturbance), but do not assess the severity of them [4–6]. The aim of our study was to examine whether the detailed severity assessment of these items can improve the overall ability of CPSS to detect LVO in AIS patients.

Methods

Study population

We have performed a cross-sectional analysis based on a prospectively collected registry of consecutive patients with first ever AIS, who were admitted up to 6 hours after symptom onset to the CSC of three university hospitals between November 2017 and July 2019. Demographic data, vascular risk factors, baseline clinical variables and onset to assessment times were recorded on admission, along with detailed evaluation of the National Institutes of Health Stroke Scale (NIHSS). Our outcome of interest was the presence of LVO on the on admission computed tomography angiography (CTA) scan, evaluated by trained neuroradiologists. NIHSS was assessed before CTA was performed. Unilateral occlusion of the intracranial internal carotid artery, M1, M2 or M3 segments of the middle cerebral, tandem occlusions, vertebral artery and basilar artery occlusions were considered. Patients who did not have CTA scan on admission were excluded.

Scale design

We derived CPSS from four items of NIHSS (item 4: facial palsy, item 5: unilateral upper extremity weakness, item 9: language and item 10: dysarthria) according to *Kothari et al*. [4]. We designed a detailed version of CPSS (d-CPSS) derived from the same NIHSS items, but without being converted to bivariate as in CPSS. Detailed scoring criteria are shown in Table 1. The ability of d-CPSS to discriminate an LVO was compared to the ability of CPSS and NIHSS.

Table 1
Detailed scoring of CPSS and d-CPSS compared to NIHSS scores

Severity of symptoms	CPSS score	d-CPSS score	NIHSS source item and score	
ARM			Item 5: arm motor drift	
No drift for 10 seconds	0	0	0	
Drift, but does not hit bed	1	1	1	
Some effort against gravity	1	2	2	
No effort against gravity	1	3	3	
No movement	1	4	4	
FACIAL PALSY			Item 4: facial palsy	
Normal symmetry	0	0	0	
Minor paralysis	1	1	1	
Partial paralysis	1	2	2	
Complete paralysis	1	3	3	
SPEECH			Item 9: aphasia	Item 10: dysarthria
Normal	0	0	0	0
Mild/moderate aphasia or dysarthria	1	1	1	1
Severe aphasia or dysarthria	1	2	2	2
Global aphasia or anarthic or mute	1	3	3	2
TOTAL	0–3	0–10		

Abbreviation: CPSS, Cincinnati Prehospital Stroke Scale; d-CPSS, detailed CPSS; NIHSS, National Institutes of Health Stroke Scale.

Statistical analysis

Data analysis was performed using SPSS (version 26.0, IBM, New York). Continuous variables were presented as mean and standard deviation (SD) or as median and interquartile range (IQR) where appropriate. Categorical variables were presented as counts and percentages. Comparison of continuous variables were performed using *t* test or *Mann-Whitney U* test. Normality was assessed using the *Shapiro-Wilk* test and visually, based on Q-Q plots and histograms. Categorical data were compared using the *Pearson* X^2 test. Binary logistic regression was used to assess associations between baseline clinical variables and the presence of LVO. Adjustment was made for baseline characteristics, $P < 0.1$ in the univariable analysis was used as inclusion threshold for multivariable analysis. The ability of scales to detect the presence of LVO and optimal cut-off points was assessed using the receiver operating characteristic (ROC) analysis. Area under the curve (AUC) was calculated for each scale and *z* test was used for comparison. Sensitivity (SN), specificity (SP), positive and negative predictive values and accuracy were calculated for different cut-off values. Where appropriate 95% confidence intervals (CI) were presented. A P value < 0.05 was considered statistically significant.

Results

During the study period 528 patients were screened, 421 (79.7%) of whom underwent CTA imaging. The mean age of the study cohort was 67.2 ± 13.2 years (48.7% female), 183 patients had LVO (43.5%). Baseline demographics and clinical factors of the two studied groups (according to the presence of LVO) are shown in Table 2. On admission CPSS, d-CPSS and NIHSS scores were significantly higher in those with LVO. The frequency of upper extremity weakness (92.3% vs. 71.8%, $p < 0.001$) and facial palsy (85.8% vs. 69.8%, $p < 0.001$) were higher among LVO patients, but there was no significant difference in the presence of speech disturbance between the groups (77.0% vs. 74.5%, $p = 0.408$). After adjustment for potential confounders, significant associations were observed between LVO and: (i) known atrial fibrillation (AF) (OR: 2.564, $p < 0.001$); (ii) systolic blood pressure (SBP) on admission (OR: 0.990, $p = 0.046$); (iii) the presence of upper extremity weakness (OR: 5.370, $p < 0.001$); and (iv) the presence of facial palsy (OR: 3.107, $p < 0.001$). Increasing severity of all three investigated symptoms were independently associated with higher odds of LVO presence. Higher CPSS, d-CPSS and NIHSS scores were also associated with increased odds of LVO (detailed results are presented in **Table S1** in the Supplementary material).

Table 2
Demography and clinical characteristics of the cohort according to the presence of LVO

	LVO present (N = 183)	**LVO absent (N = 238)**	**P value**
Age, years, median (IQR)	67 (60–78)	69 (58.75–76.25)	0.652
Gender, female, % (n)	52.5 (96)	45.8 (109)	0.175
NIHSS score, median (IQR)	11 (6–16)	6 (4–9)	**< 0.001**
CPSS score, median (IQR)	3 (2–3)	2 (2–3)	**< 0.001**
d-CPSS score, median (IQR)	5 (3–7)	3 (2-4.25)	**< 0.001**
Onset-to-assessment time, min, median (IQR)	80 (58-121.25)	92 (58.75-137.25)	0.053
On admission SBP, mmHg, mean (SD)	159.0 (30.3)	167.8 (29.9)	**0.003**
On admission DBP, mmHg, mean (SD)	88.2 (16.0)	91.2 (17.1)	0.066
Smoking, % (n), 51 missing	37.0 (57)	31.5 (68)	0.267
Hypertension, % (n), 15 missing	79.5 (140)	79.6 (183)	0.996
Diabetes mellitus, % (n), 19 missing	19.4 (34)	26.0 (59)	0.122
Hyperlipidaemia, % (n), 37 missing	55.7 (93)	55.3 (120)	0.939
Atrial fibrillation, % (n), 23 missing	35.8 (62)	16.9 (38)	**< 0.001**
Coronary artery disease, % (n), 29 missing	25.9 (45)	17.4 (38)	**0.042**
Chronic heart failure, % (n), 25 missing	14.4 (25)	8.1 (18)	**0.047**

Abbreviation: LVO, large vessel occlusion; NIHSS, National Institutes of Health Stroke Scale; IQR, interquartile range; CPSS, Cincinnati Prehospital Stroke Scale; d-CPSS, detailed CPSS; SBP, systolic blood pressure; DBP, diastolic blood pressure; SD, standard deviation.

Using a ROC analysis, the AUC value of d-CPSS was significantly higher compared to the AUC value of CPSS itself (0.788, 95% CI: 0.743 to 0.832 vs. 0.633, 95% CI: 0.580 to 0.686; $p < 0.001$). The AUC for NIHSS was 0.795 (95% CI: 0.751 to 0.839), which was not significantly different from the AUC for d-CPSS ($p = 0.510$). ROC curves are presented in Fig. 1. The optimal cut-off scores to discriminate an LVO were CPSS = 3 (SN: 64.5%, SP: 58.4%), d-CPSS ≥ 5 (SN: 69.9%, SP: 75.2%) and NIHSS ≥ 11 (SN: 64,5%, SP: 87.0%) respectively (**Table S2** in the Supplementary material).

Discussion

The main finding of our study is that detailed severity assessment of CPSS items (upper extremity weakness, facial palsy and speech disturbance) could significantly increase the ability of CPSS to discriminate the presence of LVO in AIS patients.

Currently NIHSS is the gold-standard of stroke severity assessment and it has good ability to detect LVO [7]. However, its complexity, time-consuming nature and the need for a special training can make its application in emergency situations or prehospital environment challenging [8]. Our results suggest that a detailed evaluation of CPSS may have similar capabilities as NIHSS to predict the presence of LVO, nonetheless, both NIHSS and d-CPSS still misdiagnose a significant proportion of stroke patients.

Over the past few years, attempts have been made to develop new, shorter and modified LVO detection scales in order to fit them for prehospital use, but only few have been examined extensively yet and only a minority of them have been implemented into the practice of EMS [9]. Since CPSS is one of the most widely used and well-established scales in the field of stroke assessment, it would be obvious to optimize this scale for early LVO detection.

Our results are consistent with previous studies suggesting that certain baseline variables (e.g. known AF, SBP on admission) and the presence of certain symptoms (especially aphasia, neglect and hemiparesis) are related to the presence of LVO [10, 11]. The presence of speech disturbance is not, but its severity was associated with LVO in our study, which highlights how severity assessment may improve stroke scales. Weighting of scale items or adding anamnestic data (such as AF) to stroke scales could improve their ability to predict LVO in AIS [11, 12].

Based on previous result and the findings of our study, we think that future studies should focus on optimizing existing stroke scales to LVO detection, instead of developing new ones. More detailed severity assessment or proper weighting of symptoms could be a good perspective and adding items to scales that are strongly associated with LVO could also be beneficial and should be considered. Prehospital prospective validation of these scales and comparison of their predictive power should also be the scope of further studies. Furthermore, the impact of such scales on prehospital pathways in cases of different likelihoods of LVO should also be clarified.

The retrospective analysis of prospectively collected data is the main limitation of our study. Besides, we only examined patients with AIS, and we did not have data on patients with haemorrhagic stroke and stroke-mimics. A significant proportion of screened AIS patients did not have CTA imaging, mainly due to minor symptoms (**Table S3** in the Supplementary material), which may have caused selection bias. It is important to highlight that we did not prospectively validate d-CPSS in this study, however we intend to do so in the future, with the abovementioned considerations in mind.

Conclusions

In conclusion, we can say that detailed severity assessment of symptoms can improve the ability of CPSS to detect LVO in AIS, while remaining simple to perform. Despite the remarkable number of stroke scales developed, future studies should focus on optimizing existing well-established scales, aiming to provide a faster triage and therapeutic intervention for AIS patients with LVO.

List Of Abbreviations

EVT endovascular thrombectomy

LVO large vessel occlusion

AIS acute ischemic stroke

EMS emergency medical service

CSC comprehensive stroke centre

CPSS Cincinnati Prehospital Stroke Scale

NIHSS National Institutes of Health Stroke Scale

CTA computed tomography angiography

d-CPSS detailed Cincinnati Prehospital Stroke Scale

SD standard deviation

IQR interquartile range

ROC receiver operating characteristic

AUC area under the curve

SN sensitivity

SP specificity

CI confidence interval

OR odds ratio

AF atrial fibrillation

SBP systolic blood pressure

Declarations

Ethical approval and consent to participate

The study protocol was approved by the Local Ethics Committee at University of Pécs, Faculty of Medicine (35403-2/2017/EKU). Written informed consent was obtained from each patient according to the Good Clinical Practice (GCP) guidelines.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Disclosures

The authors declare no conflict of interest.

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Author contribution statement

GT designed the study, performed literature search, data acquisition and analysis, statistical analysis and wrote the manuscript. PC performed data analysis and reviewed the manuscript. IS performed data collection, data analysis and reviewed the manuscript. EF performed data acquisition and reviewed the manuscript. AA performed data collection, data analysis and literature research. TM performed literature research, statistical analysis, reviewed and approved the manuscript. LS is the guarantor and designed the concepts of the study, interpreted the data, reviewed and approved the manuscript.

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Figures

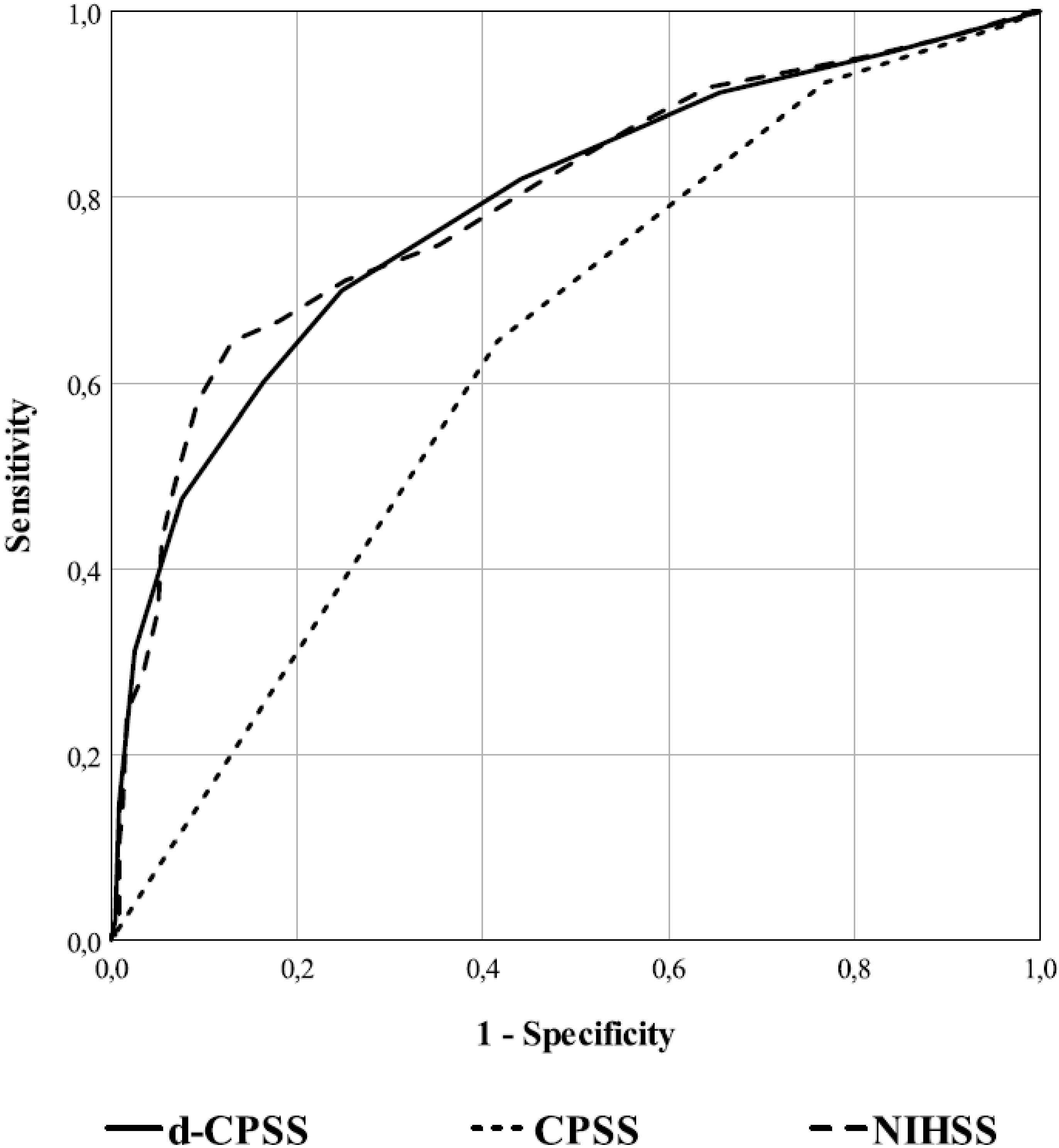

Figure 1

Receiver operating characteristic curves describing the capability of investigated scales to confirm a large vessel occlusion in acute ischemic stroke: Cincinnati Prehospital Stroke Scale (CPSS), detailed CPSS (d-CPSS) and National Institutes of Health Stroke Scale (NIHSS).

Supplementary Files

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