British Journal of Medicine & Medical Research
13(11): 1-7, 2016, Article no.BJMMR.23887
ISSN: 2231-0614, NLM ID: 101570965

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The Totaled Health Risks in Vascular Events (THRIVE) Score Predicts Ischemic Stroke Outcomes

Hesna Bektas[1*], Sadiye Gumusyayla[2], Gonul Vural[2], Asli Bolayir[1] and Orhan Deniz[2]

[1]Department of Neurology, Atatürk Training and Research Hospital, Ankara, Turkey.
[2]Department of Neurology, Yıldırım Beyazıt University Medical School, Ankara, Turkey.

Authors' contributions

This work was carried out in collaboration between all authors. Authors HB and AB designed the study, wrote the protocol and collected the data. Author HB wrote the first draft of the manuscript. Authors SG and GV managed the literature searches. Author OD edited the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJMMR/2016/23887
Editor(s):
(1) Vijay K. Sharma, Division of Neurology, Yong Loo Lin School of Medicine, National University of Singapore, National University Hospital, Singapore.
Reviewers:
(1) Adria Arboix, University of Barcelona, Barcelona, Catalonia, Spain.
(2) Mario Guidotti, Valduce Hospital General Como, Italy.
Complete Peer review History: http://sciencedomain.org/review-history/13352

Original Research Article

Received 28th December 2015
Accepted 8th February 2016
Published 18th February 2016

ABSTRACT

Objective: Assessment of the outcome after an ischemic stroke is important both to serve as a baseline for the evaluation of therapeutic measures and for rehabilitation and health planning. Our aim was to compare the Total Health Risks in Vascular Events (THRIVE) score with outcome scores and infarct volumes.
Methods: We retrospectively reviewed our stroke registry for the period 12/2012–12/2013 and identified patients diagnosed with ischemic stroke. We included patients who had undergone Diffusion-Weighted Magnetic Resonance Imaging (DW-MRI) within 24 hours of their stroke. One of the investigators reviewed all the DW-MRI images to verify infarct volumes. The periphery of the lesion area in each section was drawn by hand, and the surface area of the section was automatically calculated in mm^2 by PACS (Picture Archiving and Communication System software), which was installed on the computer. The areas were summed, and the result was multiplied by the section thickness to calculate infarct volumes. The THRIVE scores were calculated. Infarct volumes and clinical outcomes, as measured by Modified Rankin Scale (mRS)

**Corresponding author: E-mail: hesnabek-1@hotmail.com;*

and Barthel Index (BI), were compared to initial THRIVE score subgroups of 0–2 and ≥3.
Results: We included 153 (65 female, 88 male) patients in the study. The mean age was 68.30±12.07 years. The median infarct volume was 4.10 cm3 (Interquartile range (*IQR)*:19.180). An increasing THRIVE score was independently associated with an increasing likelihood of poor outcome (mRS≥3: odds ratio, 2.140; 95% confidence interval, 1.068–4.290; BI<60: odds ratio, 0.335; 95% confidence interval, 0.149–0.751). There was no significant difference in infarct volumes between the THRIVE score subgroups of 0–2 and ≥3 (*P*=0.43).
Discussion: The THRIVE score is simple to use and predicts long-term neurological outcomes in ischemic stroke patients.

Keywords: Ischemic stroke; infarct volumes; THRIVE score; outcomes.

1. INTRODUCTION

Estimation of prognosis following an ischemic stroke can inform patients and families about the probability of recovery. In addition, assessment of the outcome after an ischemic stroke is also important for rehabilitation and health care planning. Clinical variables, such as age and the National Institutes of Health Stroke Scale (NIHSS) score, have consistently been associated with outcomes after ischemic stroke [1]. Interest has recently focused on clinical and neuroradiological data for the evaluation of ischemic stroke outcomes.

The Total Health Risks in Vascular Events (THRIVE) score was first used to predict clinical outcomes among patients in the Mechanical Embolus Removal in Cerebral Ischemia (MERCI) trial, the Multi-MERCI trial, the Thrombectomy Revascularization of large Vessel Occlusions (TREVO-2) trial, and the Virtual International Stroke Trials Archive (VISTA) trial [2,3,4]. The THRIVE score takes into account age, stroke severity, and comorbidities, all of which are strong risk factors for clinical outcome. So, we hypothesized that this score might be useful for predicting prognosis after ischemic stroke and might be associated with infarct volumes. Our aim in this study was to compare THRIVE scores with available outcome scores and infarct volumes.

2. MATERIALS AND METHODS

We retrospectively reviewed our stroke registry for the period 12/2012–12/2013 and identified patients diagnosed with ischemic stroke. We included the patients who had undergone Diffusion-Weighted Magnetic Resonance Imaging (DW-MRI) within 24 hours of their stroke in our analysis. One of the investigators was blinded to clinical outcomes and independently reviewed all the DW-MRI images to verify infarct volumes. Infarct volumes were measured by regions of interest hand-drawn around each infarct area, separately in each slice. Demographic characteristics and baseline clinical information that were extracted from medical records included NIHSS and the history of Diabetes Mellitus(DM), Hypertension(HT), Atrial fibrillation(AF) at admission and the Modified Rankin Scale (mRS) and Barthel Index (BI) at the time of discharge. THRIVE scores were calculated and then analyzed regarding infarct volumes and clinical outcomes as measured by mRS and BI.

The following data were recorded for each patient to calculate the THRIVE score: age, initial stroke severity as measured by the NIHSS score, and the presence or absence of HT, DM and AF.

The THRIVE score

NIHSS	Points
≤10	0
11-20	2
≥21	4
Age	
≤59	0
60-79	1
≥80	2
(1 point each for HT, DM, AF)	
0	0
1	1
2	2
3	3
Total:	0-9

THRIVE scores range from 0 to 9. The scores were categorized as mild (0–2) and moderate-severe (3–9) for our analysis.

2.1 mRS and BI

Our outcome measures were functional outcomes on the mRS (a good outcome was 0–2, and a poor outcome was 3–6) and BI (a good

outcome was ≥60, and a poor outcome was <60) at the time of discharge.

2.2 Statistical Analyses

The Shapiro-Wilks test was used to determine the continuous variables with a normal distribution, such as age and infarct volumes. Variables not normally distributed were described using median and interquartile range. Mean and standard deviation (mean±SD) values were determined for variables with a normal distribution. The number (*n*) and percent (%) values were given for categorical variables.

The *χ2* or Fisher's exact test was used to compare group data for categorical variables. Results were reported as percentages or as odds ratios (ORs) with 95% confidence intervals (CIs), as appropriate. The Mann-Whitney *U* test was used to compare group data for continuous variables. The Kruskal-Wallis test was used to compare for nonparametric variables.

All statistical analyses were performed with the IBM SPSS Statistics 21.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) and MS-Excel 2007 software programs. The statistical significance level was set at $P<0.05$.

3. RESULTS

We included 153 (65 female, 88 male) patients that met our inclusion criteria in the study. The mean age of the patients was 68.30±12.07 (34–87) years. The mean age was 71.43±11.94 (35–87) years for females and 65.99±11.70 (34–86) years for males. The median baseline infarct volume was 4.10 cm^3 (Interquartile range (*IQR)* =19.180).

On admission, baseline information on NIHSS, and risk factors (HT, DM, and AF) were collected. Clinical prediction scores (THRIVE, mRS, and BI) were determined at the time of discharge. Stroke subtypes of the patients were classified based on clinical features and the results of diagnostic studies by a blinded neurologist.The median length of hospitalization was 11 days and ranged from 7 to 22 days. Mild mRS scores were found in 68.4% (*n*=104) of the patients, and 31.6% (*n*=48) of the patients had moderate-to-severe mRS scores. The values BI ≥60 and BI< 60 were detected in 120 and 32 patients, respectively. The THRIVE scores were between 0–2 in 89 patients (58.2%) and ≥ 3 in 64 patients (41.8%). These data are summarized in Table 1.

The mRS scores were mild in 75.3% (*n*=67) and moderate-to-severe in 24.7% (*n*=22) of the patients who had mild THRIVE scores. There was a statistically significant relationship between the THRIVE scores and mRS scores. The group with a THRIVE score ≥3 had significantly higher rates of mRS score ≥3 ($P=0.05$) (Table 2). Logistic regression showed that an increase in THRIVE score was associated with an increase in mRS score. The OR was 2.140 (95% CI, 1.068–4.290).

The BI was ≥60 in 86.5% (*n*=77) and <60 in 13.5% (*n*=12) of the patients with a mild THRIVE score. There was a statistically significant relationship between the THRIVE and BI levels of the patients ($P=0.01$). Poor outcome scores were significantly more common when the initial THRIVE scores were ≥3 (Table 2). Logistic regression showed an increase in THRIVE score was associated with a decrease in BI score. The OR was 0.335 (95% CI, 0.149–0.751).

The mean infarct volume was 3.80 cm^3 (*IQR*=17.91) in the patients with a mild THRIVE score and 4.47 cm^3 (*IQR*=19.67) in those with a moderate-to-severe score. There was not a significant relationship between infarct volumes in the mild THRIVE score group, nor those in the moderate-to-severe group ($P=0.43$) (Table 3).

Each of the ischemic strokes was assigned a subtype:large-vessel atherosclerosis,66 (43.1%); cardioembolic, 17 (11.1%); lacunar, 26(17%); uncertain cause, 31 (20.3%); and other or unusual causes, 13 (8.5%). There was not a significant relationship between stroke subtypes and NIHSS at admission and discharge, mRS, BI and THRIVE scores ($P= 0.87$, $P= 0.64$, $P= 0.91$, $P= 0.94$, $P= 0.66$ respectively). We categorized the patients as lacunar and nonlacunar ischemic strokes. We couldn't find any significance in terms of NIHSS at admission and discharge, mRS, BI and THRIVE scores. (z:0.349, $P=0.72$; z:0.173 $P=0.86$;z=0.049 $P=0.96$; z=0.676, $P=0.50$;z=1.251 $P=0.21$ respectively).

4. DISCUSSION

Many modifiable and nonmodifiable factors measurable at admission have been shown to influence clinical outcomes following acute ischemic stroke. Modifiable predictors of outcome include vessel recanalization, blood

pressure, glucose level, patient temperature, and care in an organized stroke unit. Nonmodifiable predictors of outcome include age, initial ischemic stroke severity, ischemic stroke territory and subtype, imaging findings, and medical comorbidities [5].

The usefulness of neuroimaging to predict outcomes has not been definitively established. DW-MRI is able to demonstrate areas of cerebral infarction within hours of symptom onset. However, some previous studies have found a strong association between DW-MRI infarct volumes and outcomes, whereas others have not supported a strong relationship [6,7,8]. Johnston et al. reported that baseline DW-MRI lesion volume data in acute ischemic stroke had no clinically significant effect on outcome prediction, due to the dynamic of infarct volumes in the early hours and days after acute ischemic stroke

Table 1. Characteristics of patients with acute ischemic stroke enrolled to the study

	n	**%**
Age mean±SD (min; max)	**68.30±12.07 (min: 34; max: 87)**	
Gender		
• Female	65	42.5
• Male	88	57.5
Risk factors		
• Diabetes mellitus	52	34.0
• Atrial fibrillation	31	20.3
• Hipertansiyon	106	69.3
Infarct volume (cm^3) median (IQR)	**4.10 (19.180) (min: 0.20; max: 205.40)**	
NIHSS (admission)		
• Minor (0-4)	99	64.7
• Moderate (5-15)	48	31.4
• Moderate-severe (16-20)	6	3.9
NIHSS (discharge)		
• Minor (0-4)	104	68.4
• Moderate (5-15)	43	28.3
• Moderate-severe (16-20)	5	3.3
Modified Rankin scale (mRS)		
• Mild (0-2)	104	68.4
• Moderate-severe (≥3)	48	31.6
Barthel index (BI)		
• Good outcome ≥60	120	78.9
• Poor outcome <60	32	21.1
THRIVE		
• Mild (0-2)	89	58.2
• Moderate-severe (≥3)	64	41.8
Stroke subtypes		
• Large- artery atherosclerosis	66	43.1
• Cardioembolism	17	11.1
• Small-vessel occlusion	26	17
• Other determined etiology	31	20.3
• Undetermined etiology	13	8.5

Table 2. Comparison of THRIVE scores with mRS and BI

	THRIVE score		**Test statistics**	
	0-2 *n* (%)	**≥3 *n* (%)**	χ^2	***P***
mRS score 0-2	67 (75.3)	37 (58.7)		
mRS score ≥3	22 (24.7)	26 (41.3)	3.942	0.05
BI ≥60	77 (86.5)	43 (68.3)		
BI <60	12 (13.5)	20 (31.7)	6.345	0.01

Table 3. The relationship between THRIVE and infarct volumes

	THRIVE (Mild) Median (IQR) (min; max)	THRIVE (Moderate-severe) Median (IQR) (min; max)	*Z*	*p*
Infarct volume (cm^3)	3.80 (17.91) (0.20; 205.40)	4.47 (19.67) (0.50; 59.89)	0.795	0.43

and the influence of biological markers [9]. Barrett et al. reported that an early change in DW-MRI infarct volumes after ischemic stroke and functional outcomes supported the conclusion that the likelihood of achieving an excellent outcome diminished substantially with growth in DW-MRI lesion volume (10 cm^3) in the first 5 days after stroke of mild-to-moderate severity [6]. We did not find any association between mRS, BI, and DW-MRI infarct volumes in this study, possibly due to the inclusion of patients who had undergone DW-MRI in the first 24 hours after symptom onset and also the influence of collateral flow patterns, systemic blood pressure, reperfusion, and excitotoxicity on early volumes after large vessel occlusion.

Estimation of the probability of recovery after ischemic stroke is important for patients, families and neurologists in clinical practice. Neurologists prefer to determine the outcome prediction score at the patient's bedside and believe that the score must have the ability to adequately predict outcomes.

Several prognostic scores have been introduced to predict ischemic stroke outcomes, such as those suggested by Weimar et al. [10] and Counsell et al. [11] (the Six Simple Variable score), the Bologna Outcome Algorithm for Stroke scale [12], the iScore [13], the PLAN score [14], the ASTRAL score [15], and the DRAGON score [16]. However, these scores have many variables and most of them require neuroimages. Therefore, the THRIVE score has some advantages. It is simple to calculate and is based on clinical factors known to the clinician immediately upon the patient's presentation without requiring neuroimaging or laboratory testing [17,18].

Arboix et al. reported that lacunar infarcts were the stroke subtype with a better functional prognosis [19] and prior TIA was associated with a favorable outcome in nonlacunar ischemic stroke, suggesting a neuroprotective effect of TIA possibly by inducing a phenomenon of ischemic tolerance allowing better recovery from a subsequent ischemic stroke [20]. However we could not find any relationship between the NIHSS, mRS, BI and THRIVE scores in stroke subtypes and in lacunar and nonlacunar infarcts.

We used the THRIVE score in this study, as it is simple and easy to calculate. The patients with moderate-to-high THRIVE scores had the worst outcome scores at the time of discharge, as measured by mRS and BI. We found that THRIVE scores strongly predicted clinical outcomes. We found no significant relationship between THRIVE scores and infarct volumes.

Our study had a few limitations. Outcome scores at three months because of the retrospective study design and the absence of a three-month follow-up appointment. The study group was also not large enough to compare the differences between moderate and high THRIVE scores.

5. CONCLUSION

The results of this limited registry have shown that the THRIVE score is a rapid and reliable tool for predicting functional outcomes and the risk of disability in patients with acute ischemic stroke.

CONSENT

All authors declare that 'written informed consent form' was obtained from the patients.

ETHICAL APPROVAL

All authors hereby declare that the study was approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

FUNDING

This research received no grant from any funding agency in the public, commercial, or non-profit sectors.

ACKNOWLEDGEMENTS

The authors state no additional individuals to acknowledge.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/13352