VALIDATION AND COMPARISON OF NONCONTRAST CT SCORES TO PREDICT INTRACEREBRAL HEMORRHAGE EXPANSION

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Background and purpose: the BAT, BRAIN and HEP scores have been proposed to predict hematoma expansion (HE) with noncontrast CT (NCCT). We sought to validate these tools and compare their diagnostic performance.

Methods: we retrospectively analyzed two cohorts of patients with primary intracerebral hemorrhage. HE was defined as volume growth >33% or >6 mL. Two raters analyzed NCCT scans and calculated the scores, blinded to clinical and imaging data. The inter-rater reliability was assessed with the interclass correlation statistic. Discrimination and calibration were calculated with area under the curve (AUC) and Hosmer-Lemeshow χ^2 statistic respectively. AUC comparison between different scores was explored with DeLong test. We also calculated the sensitivity, specificity, positive and negative predictive values of the dichotomized scores with cutoffs identified with the Youden's index.

Results: a total of 230 subjects were included, of whom 86 (37.4%) experienced HE. The observed AUC for HE were 0.696 for BAT, 0.700 for BRAIN and 0.648 for HEP. None of the scores had a significantly superior AUC compared with the others (all $p > 0.4$). All the scores had good calibration (all $p > 0.3$) and good to excellent inter-rater reliability (interclass correlation > 0.8). BAT > 3 showed the highest specificity (0.81) whereas BRAIN > 6 had the highest sensitivity (0.76).

Conclusions: the BAT, BRAIN and HEP scores can predict HE with acceptable discrimination and require just a baseline NCCT scan. These tools may be used to stratify the risk of HE in clinical practice or randomized controlled trials.

Table 1. Comparison between patients with and without ICH expansion.

	ICH Expansion		
	NO (n = 144)	YES (n = 86)	P
Age, median (IQR), y	71 (63 - 79)	77 (69 - 83)	0.001
Sex, male, n (%)	86 (59.7)	50 (58.1)	0.813
History of hypertension, n (%)	123 (85.4)	76 (88.4)	0.525
Antiplatelet treatment, n (%)	37 (25.7)	37 (43.0)	0.006
Warfarin treatment, n (%)	13 (9.0)	16 (18.6)	0.034
Admission GCS, median (IQR)	15 (14 - 15)	14 (12 - 15)	<0.001
Baseline ICH volume, median (IQR), mL	8 (4 - 15)	23 (7 - 62)	<0.001
IVH presence, n (%)	39 (27.1)	25 (29.1)	0.745
ICH Location			
Deep, n (%)	82 (56.9)	41 (47.7)	0.184
Lobar, n (%)	48 (33.3)	39 (45.3)	
Infratentorial, n (%)	14 (9.7)	6 (7.0)	
Time from onset to baseline NCCT			
< 1 h, n (%)	6 (4.2)	3 (3.5)	0.044
1-2 h, n (%)	33 (22.9)	27 (31.4)	
2-3 h, n (%)	25 (17.4)	17 (19.8)	
3-4 h, n (%)	13 (9.0)	10 (11.6)	
4-5 h, n (%)	10 (6.9)	12 (14.0)	
> 5 h, n (%)	57 (39.6)	17 (19.8)	
Blend sign, n (%)	10 (6.9)	19 (22.1)	0.001
Hypodensities, n (%)	51 (35.4)	65 (75.6)	<0.001
SAH, n (%)	17 (11.8)	36 (41.9)	<0.001
BAT score, median (IQR)	2 (0 - 2)	2 (2 - 4)	<0.001
BRAIN score, median (IQR)	5 (2 - 9)	9 (6 - 11)	<0.001
HEP score, median (IQR)	3 (0 - 5)	5 (3 - 6)	<0.001
Mortality at 90 days, n (%)	10 (6.9)	19 (22.1)	0.001

Table 3. Dichotomized scores test characteristics

Test characteristics	BAT score ≥ 3	BRAIN score ≥ 6	HEP score ≥ 4	p
Sensitivity (95% CI)	0.49 (0.38 - 0.60)	0.76 (0.65-0.84)	0.59 (0.48 - 0.70)	0.001
Specificity (95% CI)	0.81 (0.74 - 0.87)	0.61 (0.53-0.69)	0.63 (0.55 - 0.71)	<0.001
PPV (95% CI)	0.61 (0.48 - 0.72)	0.54 (0.48-0.60)	0.49 (0.42 - 0.56)	0.311
NPV (95% CI)	0.73 (0.65 - 0.79)	0.81 (0.74-0.86)	0.72 (0.66 - 0.78)	0.239