SUPPLEMENTAL FILES

The prognostic value of CT angiography and CT perfusion in acute ischemic stroke

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Supplemental Table 1. Univariable analyses between patient characteristics and non-contrast CT measures and poor clinical outcome, within derivation set (n=824)

Predictor	OR (95% CI)	PPV
Patient characteristics		
Age (per decade)	1.42 (1.27-1.59)***	
Lowest tertile (<63.0 years)		26%
Middle tertile (63.0-75.1 years)		31%
Highest tertile (≥75.1 years)		49%
Stroke severity (NIHSS)		
NIHSS 1-2	1.00 (reference)	6%
NIHSS 3-4	3.64 (1.67-7.96)**	20%
NIHSS 5-7	6.04 (2.85-12.79)***	29%
NIHSS 8-13	10.14 (4.84-21.23)***	41%
NIHSS >13	34.88 (16.52-73.67)***	71%
Time from symptom onset to scan (per hour)	1.03 (0.96-1.11)	
Lowest tertile (≤84 minutes)		39%
Middle tertile (84-142 minutes)		33%
Highest tertile (≥142 minutes)		34%
Pre-admission mRS >2	10.40 (4.80-22.54)***	83%
Admission glucose level (per mmol/L)	1.14 (1.07-1.22)***	
Lowest tertile (≤6.1 mmol/L)		28%
Middle tertile (6.1-7.3 mmol/L)		36%
Highest tertile (≥7.3 mmol/L)		44%
IV-rtPA, intra-arterial thrombolysis, or mechanical thrombectomy	1.07 (0.79-1.45)	36%
Non-contrast CT measures		
Hyperdense vessel sign	3.78 (2.70-5.30)***	60%
ASPECTS ≤7[†]	4.21 (2.62-6.75)***	66%

Abbreviations: OR, odds ratio; CI, confidence interval; PPV, positive predictive value; NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin Scale; IV-rtPA, intravenous thrombolysis with recombinant tissue type plasminogen activator; ASPECTS, Alberta Stroke Program Early CT Score.
* p<0.05; ** p<0.01; *** p<0.001
[†]ASPECTS was used for patients with suspected anterior circulation stroke, and posterior circulation ASPECTS was used for patients with suspected posterior circulation stroke

Supplemental Table 2. Multivariable analyses between patient characteristics and imaging findings, and poor clinical outcome, within derivation set (n=824)

Predictor	Patient characteristics and NCCT		Addition of CTA		Addition of CTP		Addition of CTA and CTP	
	Coefficient	OR (95% CI)	Coefficient	OR (95% CI)	Coefficient	OR (95% CI)	Coefficient	OR (95% CI)
Age (per decade)	0.368	1.44 (1.26-1.66)***	0.374	1.45 (1.26-1.67)***	0.355	1.43 (1.24-1.64)***	0.370	1.45 (1.26-1.67)***
Stroke severity (NIHSS)								
NIHSS 1-2	0.000 (ref)	1.00 (ref)	0.000 (ref)	1.00 (ref)	0.000 (ref)	1.00 (ref)	0.000 (ref)	1.00 (ref)
NIHSS 3-4	1.371	3.94 (1.70-9.14)**	1.122	3.07 (1.43-6.61)**	1.140	3.13 (1.47-6.67)**	1.134	3.11 (1.44-6.70)**
NIHSS 5-7	1.940	6.96 (3.06-15.79)***	1.653	5.23 (2.48-10.99)***	1.640	5.16 (2.47-10.76)***	1.630	5.10 (2.42-10.76)***
NIHSS 8-13	2.304	10.02 (4.40-22.83)***	1.956	7.07 (3.33-14.99)***	1.883	6.57 (3.12-13.85)***	1.892	6.63 (3.11-14.14)***
NIHSS >13	3.573	35.62 (15.13-83.86)***	2.998	20.05 (9.07-44.29)***	2.931	18.74 (8.46-41.52)***	2.860	17.46 (7.76-39.25)***
Time from symptom onset to scan (per hour)	0.073	1.08 (0.97-1.19)	0.045	1.05 (0.95-1.16)	0.072	1.07 (0.97-1.19)	0.053	1.05 (0.95-1.17)
Pre-admission mRS >2	2.674	14.50 (5.82-36.11)***	2.492	12.09 (5.32-27.47)***	2.472	11.85 (5.24-26.77)***	2.514	12.35 (5.44-28.05)***
Admission glucose level (per mmol/L)	0.116	1.12 (1.04-1.22)**	0.117	1.12 (1.04-1.22)**	0.116	1.12 (1.04-1.22)**	0.118	1.13 (1.04-1.22)**
IV-rtPA, IAT or MT	-0.321	0.73 (0.45-1.17)	-0.426	0.65 (0.41-1.05)	-0.281	0.75 (0.48-1.20)	-0.387	0.68 (0.42-1.09)
Non-contrast CT predictors								
Hyperdense vessel sign	0.601	1.82 (1.18-2.83)**	0.196	1.22 (0.75-1.96)	0.371	1.45 (0.91-2.32)	0.103	1.11 (0.67-1.83)
ASPECTS ≤7†	0.868	2.38 (1.33-4.27)**	0.757	2.13 (1.12-4.06)*	0.609	1.84 (1.02-3.31)*	0.670	1.95 (1.02-3.74)*
CT angiography predictors								
CTA-SI ASPECTS ≤7†			-0.315	0.73 (0.42-1.28)			-0.500	0.61 (0.34-1.10)
Proximal intracranial occlusion			0.651	1.92 (1.19-3.09)**			0.589	1.80 (1.10-2.97)*
Poor leptomeningeal collaterals			0.617	1.85 (1.08-3.18)*			0.503	1.65 (0.95-2.88)
Significant carotid or vertebrobasilar stenosis			0.804	2.23 (1.42-3.51)**			0.836	2.31 (1.46-3.64)***
CT perfusion predictors								
CBV ASPECTS ≤7†					0.379	1.46 (0.81-2.63)	0.436	1.55 (0.84-2.86)
MTT ASPECTS ≤7†					0.176	1.19 (0.73-1.95)	-0.082	0.92 (0.55-1.55)
Penumbra size (per SD; 18.2 cm²)								
Infarct core size (per SD; 13.9 cm²)					0.125	1.13 (0.90-1.43)	0.116	1.12 (0.87-1.44)
Penumbra/infarct core index (per SD; 37.8%)								

Abbreviations: OR, odds ratio; CI, confidence interval; NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin Scale; IV-rtPA, intravenous thrombolysis with recombinant tissue type plasminogen activator; IAT, intra-arterial thrombolysis; MT, mechanical thrombectomy; ASPECTS, Alberta Stroke Program Early CT Score; CTA-SI, CT angiography source images; CBV, cerebral blood volume; MTT, mean transit time.
* p<0.05; ** p<0.01; *** p<0.001
†ASPECTS was used for patients with suspected anterior circulation stroke, and posterior circulation ASPECTS was used for patients with suspected posterior circulation stroke

Supplemental Table 3. Model performance

	Patient characteristics and NCCT	Model with addition of CTA	Model with addition of CTP	Model with addition of CTA and CTP
Derivation set (n=824)				
R^2	0.422	0.445	0.421	0.451
Brier score*	0.153	0.146	0.151	0.145
AUC value	0.837 (0.809-0.865)	0.852 (0.825-0.878)	0.841 (0.813-0.868)	0.853 (0.826-0.880)
Goodness-of-fit p-value[†]	0.99	0.80	0.69	0.87
Internal validation (n=824)[‡]				
R^2	0.399	0.425	0.401	0.423
Brier score*	0.159	0.153	0.158	0.153
AUC value	0.828 (0.800-0.856)[§]	0.839 (0.813-0.866)[§]	0.829 (0.801-0.856)[§]	0.839 (0.812-0.866)[§]
Validation set (n=550)				
R^2	0.302	0.343	0.310	0.342
Brier score*	0.184	0.175	0.182	0.175
AUC value	0.776 (0.735-0.817)	0.793 (0.753-0.833)	0.777 (0.736-0.819)	0.793 (0.753-0.833)
Goodness-of-fit p-value[†]	<0.001	<0.001	<0.001	<0.001
Goodness-of-fit p-value after updating intercept[†]	0.001	0.09	0.003	0.01
AUC in subgroups of patients in the validation cohort				
Anterior circulation stroke (TACS or PACS; n=361)	0.778 (0.730-0.826)	0.795 (0.749-0.842)	0.780 (0.732-0.828)	0.795 (0.749-0.841)
Posterior circulation stroke (POCS; n=80)	0.748 (0.620-0.877)	0.808 (0.695-0.921)	0.746 (0.618-0.874)	0.805 (0.690-0.920)
NIHSS ≥5 (n=315)	0.745 (0.692-0.799)	0.778 (0.728-0.829)	0.747 (0.693-0.800)	0.779 (0.728-0.829)
NIHSS ≥8 (n=215)	0.742 (0.677-0.807)	0.774 (0.713-0.836)	0.748 (0.684-0.812)	0.779 (0.718-0.840)
Pre-admission mRS 0-2 (n=515)	0.749 (0.703-0.795)	0.769 (0.724-0.813)	0.751 (0.705-0.796)	0.768 (0.723-0.812)
Treatment with IV-rtPA, IAT, or MT (n=343)	0.750 (0.695-0.805)	0.772 (0.718-0.825)	0.752 (0.698-0.807)	0.772 (0.719-0.825)
No treatment with IV-rtPA, IAT, or MT (n=207)	0.817 (0.755-0.878)	0.828 (0.769-0.887)	0.818 (0.757-0.879)	0.826 (0.767-0.886)
Proximal intracranial occlusion (n=130)	0.780 (0.702-0.859)	0.811 (0.738-0.885)	0.792 (0.716-0.869)	0.815 (0.742-0.888)

Abbreviations: NCCT, non-contrast CT; CTA, CT angiography; CTP, CT perfusion; AUC, area under the curve; mRS, modified Rankin Scale; TACS, total anterior circulation syndrome; PACS, partial anterior circulation syndrome; POCS, posterior circulation syndrome; NIHSS, National Institutes of Health Stroke Scale; IV-rtPA, intravenous thrombolysis with recombinant tissue type plasminogen activator; IAT, intra-arterial thrombolysis; MT, mechanical thrombectomy.

*Quadratic score for differences between actual outcomes and predictions, range from 0 for a perfect model to 0.25 for a non-informative model.

[†]Goodness-of-fit p-values are calculated with the Hosmer-Lemeshow test.

[‡]Internal validation with 1000 bootstraps resamples.

[§]Assuming the same standard error applies as estimated for model development.

Supplemental Table 4. Outcome prediction with patient characteristics and non-contrast CT (Excel file)

Please see the separate Excel file to use the interactive calculation sheet for prediction of clinical outcome with patient characteristics and non-contrast CT.

Supplemental Table 5. Outcome prediction with patient characteristics, non-contrast CT, CT angiography, and CT perfusion (Excel file)

Please see the separate Excel file to use the interactive calculation sheet for prediction of clinical outcome with patient characteristics, non-contrast CT, CT angiography, and CT perfusion.

Supplemental Figure I. Calibration plots for all models in the validation set.
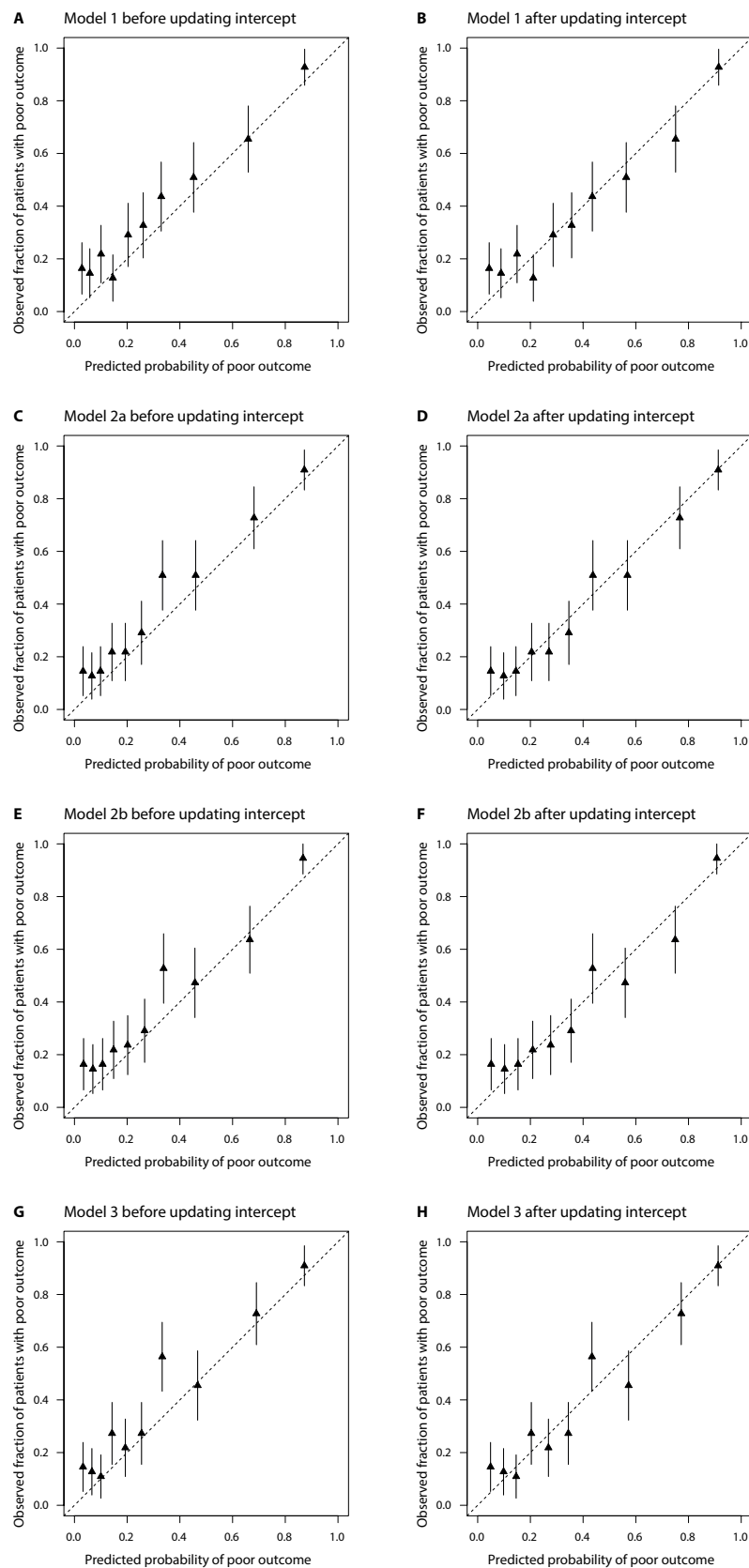
The calibration plots depict the observed fraction of patients with poor clinical outcome within deciles of predicted risk. Calibration plots are presented before (left) and after updating the model intercept (right), for the models based on patient characteristics and non-contrast CT (model 1; A, B), and with addition of CT angiography measures (model 2a; C, D), CT perfusion measures (model 2b; E, F), and both CT angiography and CT perfusion measures (model 3; G, H).

Supplemental Figure 2. Nomogram for prediction of the risk of poor clinical outcome (mRS 3-6), based on patient characteristics and non-contrast CT measures.
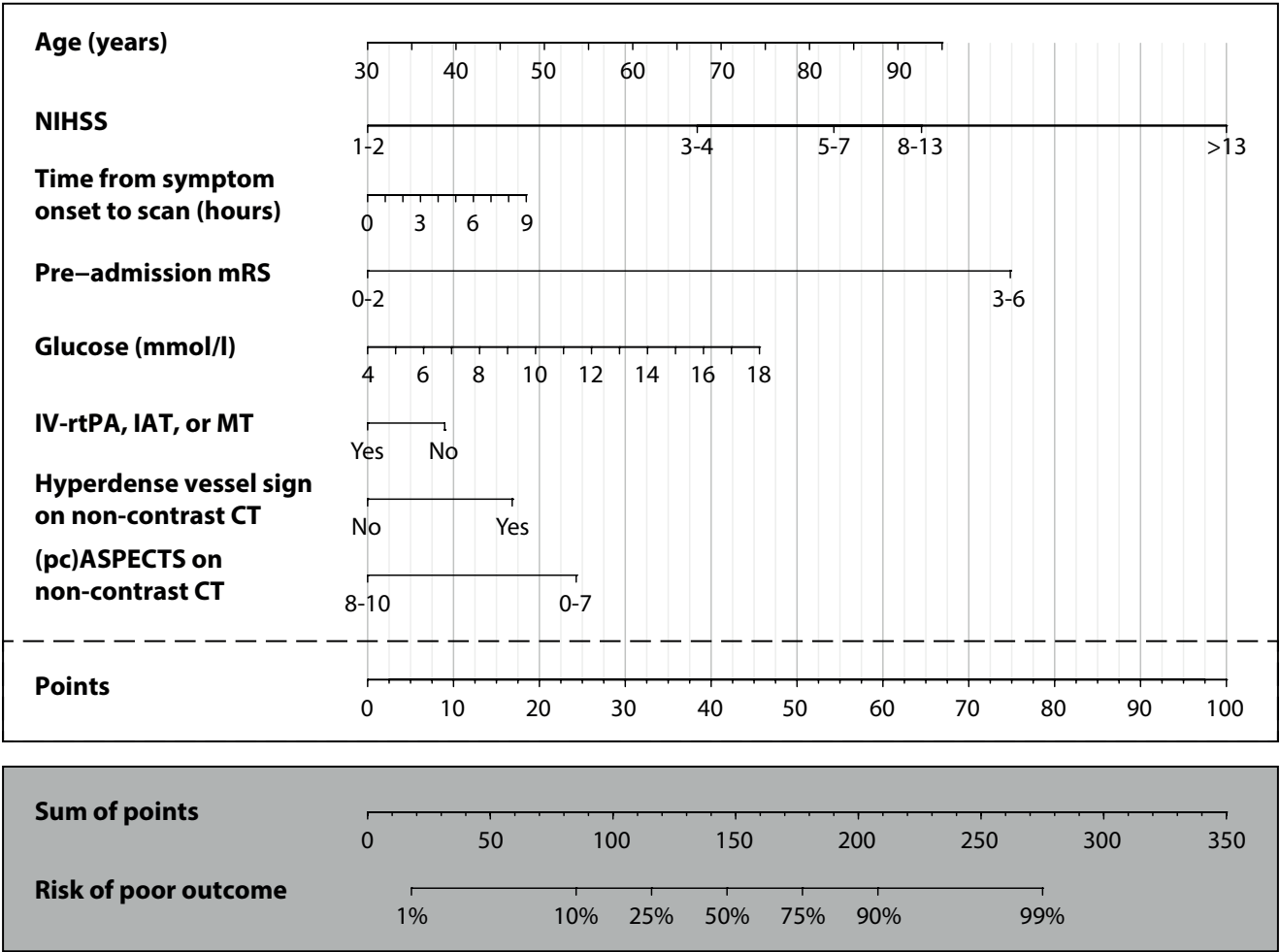
Determine the points for each predictor by locating the predictor value on its axis, and find the amount of points on the corresponding 'Points' axis. Add the points for the individual predictors together and locate this number on the 'Sum of points' axis to find the predicted risk of poor clinical outcome.

Abbreviations: NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin Scale; IV-rtPA, intravenous thrombolysis with recombinant tissue type plasminogen activator; IAT, intra-arterial thrombolysis; MT, mechanical thrombectomy; (pc)ASPECTS, (posterior circulation) Alberta Stroke Program Early CT Score