

## Neurological outcome prediction in patients with subarachnoid hemorrhage using a model based on initial CT scan, clinical data and neural networks [Abstract]

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analysed linear dependency with variables like the Fisher score and WFNS grade with the use of linear regression.

**Results:** The cvMTT in early CTP-imaging during the EBI phase of aSAH, does not significantly correlate with the dichotomized outcome after 6 months for the entire study population ( $p = 0.15$ ) nor for any of the subgroups (without EVD:  $p = 0.21$ ; with EVD:  $p = 0.3$ ). There is no significant difference in mean cvMTT, between patients with and without EVD at the time of early CTP-imaging. The cvMTT at early CTP-imaging, does not significantly correlate with initial WFNS ( $p = 0.23$ ) or Fisher grade ( $p=0.07$ ).

**Conclusions:** In the present cohort of 124 patients with aSAH, heterogeneity of MTT (cvMTT) of early cerebral perfusion imaging did not correlate with the initial WFNS-grade, Fisher grade, or outcome after six months. Therefore, the present study suggests that capillary transit time heterogeneity, as measured by cvMTT, may not play a major role in the early brain injury.

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**SHELTER-SCORE - SUBARACHNOID HEMORRHAGE ASSOCIATED EARLY BRAIN INJURY OUTCOME PREDICTION SCORE**

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Oral e-Poster Presentations - Booth 1: Vascular A (Aneurysms), September 25, 2023, 1:00 PM - 2:30 PM

**Background:** Recent experimental research supports the concept of early brain injury (EBI) as an important event in the pathophysiology of aSAH that significantly influences post-EBI events. With this work, we aimed to identify clinical/radiological outcome factors occurring during the first 72 hours after hemorrhage and to develop a rapid and easy score (SHELTER) to better predict clinical outcome.

**Methods:** We included 561 consecutive patients who were admitted to our neurovascular centre with aSAH from 01/2014-09/2022. We retrospectively analysed 14 potential clinical/radiological predictors that occurred within the first 72 hours after haemorrhage. The mRS at 6 months, discretised to three levels (0-2: favourable, 3-5: poor, 6: dead), was used as outcome-variable. Univariate ordinal regression was used to rank the predictors by significance. Forward selection and McFadden's pseudo-R2 as the optimality criterion were applied to find the optimal set of predictors for multi-variate proportional odds logistic regression. Collinear parameters were excluded five-fold cross-validation was used to avoid overfitting.

**Results:** 561 patients were included in the analysis which ultimately resulted in the SHELTER-score of 7 clinical and radiological factors with different weights: age (0-4 points), WFNS (0-2.5 points), cardiopulmonary resuscitation (2 points), mydriasis (1-2 points), midline shift (0.5-1 points), early deterioration (1 point) and early ischemia (2 points). McFadden's pseudo-R2 = 0.339, AUC for death or disability 0.899 and 0.877 for death. An EBI-score below 5 correlated with a favourable outcome (mRS 0-2), 5-6.5 with a poor outcome (mRS 3-5) and  $\geq 7$  with death (mRS 6) at 6 months, respectively.

**Conclusions:** Based on a large retrospective patient cohort, the SHELTER-score was constructed to predict clinical outcome of patients with aSAH at 6 months. This new score needs further (external) validation, ideally in a prospective setting. It may improve existing prediction methods by including pathophysiological factors occurring in the early phase of aSAH.

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**NEUROLOGICAL OUTCOME PREDICTION IN PATIENTS WITH SUBARACHNOID HEMORRHAGE USING A MODEL BASED ON INITIAL CT SCAN, CLINICAL DATA AND NEURAL NETWORKS.**

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Oral e-Poster Presentations - Booth 1: Vascular A (Aneurysms), September 25,

2023, 1:00 PM - 2:30 PM

**Background:** Subarachnoid hemorrhage(SAH) entails high morbidity and mortality. Several risk factors have been identified as mortality and functional outcome estimators. Artificial intelligence(AI) enables handling high-dimensional and complex data. Neural networks (NN), an automated machine learning technique, can be trained with images and/or data to perform accurate predictions. This study aims to predict the functional outcome of SAH patients at three months using a NN-based algorithm that processes initial CT scan images and clinical features.

**Methods:** Clinical features and CT scans of a multicentric retrospective cohort of SAH patients were analyzed. AUCMED1, an open-source Python library, was used to create and train two different NNs: one based solely on images and the other incorporating clinical features (age and WFNS). The output variable was a dichotomized modified Rankin scale at 3 months(mRS): Good Outcome=mRS<4; Bad Outcome= mRS<4. The initial dataset was randomly split into training, validation, and test cohorts at a ratio of 70%-10%-20%.

**Results:** Images and data from 219 patients were processed. 52.5% were female patients with a mean age of 57. 18.3% were idiopathic SAH. Median WFNS on admission was 2, and mortality was 28.8%. 54.3% of patients presented a good outcome at 3 months follow-up. Predicting neurological outcome, the model exclusively based on CT scan images (Accuracy=86%, F1=86% and AUC=0.89) outperformed the one based on images and clinical data (Accuracy=79%, F1=78% and AUC=0.87). Explainable Artificial Intelligence maps were built to highlight the areas the algorithm accounts on the CT scan in order to classify patients.

**Conclusions:** Modern image processing techniques based on AI and NN make possible to predict neurological outcome in SAH patients with high accuracy using CT scan images as the only input. Models might be optimized by including more data and patients, therefore improving their performance on tasks beyond the skills of conventional clinical knowledge.

**Optional Image**

METRIC	NEURAL NETWORK CLINICAL DATA+IMAGES	NEURAL NETWORK IMAGES
Sensitivity	0.78	0.85
Specificity	0.78	0.85
Precision	0.83	0.88
Accuracy	0.79	0.86
F1	0.78	0.86
AUC	0.87	0.89

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**BRAIN AND SPINE 3 (2023) 101794 101996**  
**DE NOVO INTRACRANIAL ANEURYSM FORMATION AFTER INTERNAL CAROTID ARTERY OCCLUSION: A SYSTEMATIC REVIEW OF ETIOLOGY, DIAGNOSIS, AND TREATMENT**

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Oral e-Poster Presentations - Booth 1: Vascular A (Aneurysms), September 25, 2023, 1:00 PM - 2:30 PM

**Background:** Acute ACI occlusion may lead to hemodynamic perfusion deficits leading to compensatory spontaneous hypertension that is a known risk factor to develop ICAs. Here, we review different etiologies of ACI occlusion, follow up, time to develop de novo ICA aneurysm and treatment options.

**Methods:** We searched the PubMed database using the terms "internal carotid artery occlusion" and "de novo aneurysm". A review of literature on etiology, diagnosis, and treatment of internal carotid artery occlusion and de novo aneurysm was conducted. The studies involving the management of internal carotid artery occlusion and de novo aneurysm were selected. In this review article, we mainly summarized the etiology, diagnosis, and treatment strategy of de novo aneurysm after internal carotid artery occlusion.

**Results:** A total of 23 articles were included. 183 patients [52 (28.4%) males, 75 (41.0%) females, and 56 (30.6%) unclear] suffered ICA occlusion at the mean age of 44.8±18.4 (range between 6 to 81) years. 120 (65.6%) patients caused by