

# Predictors of Long-term Functional Outcome in Subarachnoid Hemorrhage, and Proposal for a Scoring System

Luis Ascanio; Georgios Maragkos; Alejandro Enriquez-Marulanda; Mohamed Salem; Kohei Chida; Raghav Gupta; Abdulrahman Alturki; Kimberly Kicielinski; Christopher Ogilvy; Justin Moore; Ajith Thomas  
Division of Neurosurgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

## Introduction

The purpose of this study is to analyze the prognostic significance of clinical and radiologic factors during hospitalization for subarachnoid hemorrhage (SAH). Based on these factors, we propose a 4-variable, readily usable scoring system that is highly predictive of long-term neurological functional outcomes after hospitalization for SAH.

## Methods

We conducted a retrospective review of patients with aneurysmal subarachnoid hemorrhage surviving to discharge in a single academic institution in the period of 2007-2016. A comparison analysis was then performed on these patients based on unfavorable functional outcomes (modified Rankin Scale scores 2-6) at follow-up 6 to 12 months. 128 patients were included in the analysis; 99 patients (77.3%) had a good outcome and 29 (22.7%) had a bad outcome. Variables that were significant in univariate analysis were then utilized to run a multivariate logistic regression and build a predictive model. The ROC curve was used to evaluate the discriminative performance of the model for bad outcomes at 6-12 months.

Table 1. Multivariate Analysis

Variable	OR (95% CI)	P-value
Hunt Hess 4-5	5.94 (1.82 - 19.44)	<b>0.003</b>
Rebleeding	64.5 (4.77 - 870.7)	<b>0.002</b>
DCIN	9.2 (2.82 - 29.9)	<b>&lt;0.01</b>
Infection	3.3 (1.1 - 10.0)	<b>0.033</b>

## Results

Based on the results of multivariate analysis (Table 1), our new score for predicting outcomes, which ranges from 0 to 4, was tested in our cohort. The following parameters were included: Hunt & Hess score of 4-5, re-bleeding, infarction after 48 hours and clinically relevant infection. The presence of each parameter yielded 1 point. Our model had an ROC area under the curve of 79.8% for detecting bad outcomes (mRS 2-6 at 6-12 months), which was better than Hunt & Hess (63.6%), modified Fisher score (53.5%), BNI (64.4%) and WFNS (56.9%) (Figure 1). Setting a cutoff of 2 or more for bad outcome, the proposed scoring system had a sensitivity of 72.41%, specificity of 81.82% and LR+ of 3.983 for predicting mRS 2-6 (Table 2).

Table 2. Proposed Scoring System

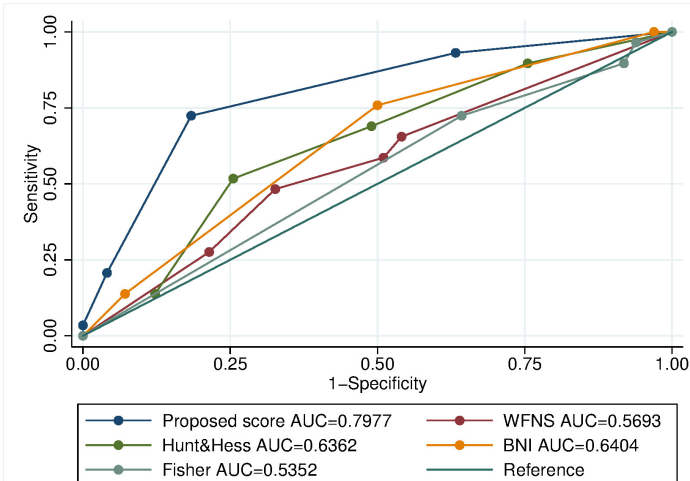
Variable	Points
Hunt & Hess 4 or 5	1
Re-bleeding	1
Infarction after 48 hours	1
Infection	1
<b>Total</b>	<b>0-4</b>

A score of 2-4 predicts 6-12 month mRS of 2-6 with sensitivity of 72.41% and specificity of 81.82%.

## Conclusions

Here we propose a four-variable grading system to predict long-term functional outcomes in patients with subarachnoid hemorrhage surviving hospitalization. Our data suggest that patients with lower scores may have better long-term functional outcomes. Our scale is usable before patient discharge to aid in patient and family expectation guidance and long-term care planning.

Figure 1. ROC comparison for all tested scales



The proposed score had significantly higher AUC than all other tested scales.

## References

- Lo BW, Fukuda H, Nishimura Y, Farrokhyar F, Thabane L, Levine MA. Systematic review of clinical prediction tools and prognostic factors in aneurysmal subarachnoid hemorrhage. *Surg Neurol Int.* 2015;6:135.
- Hunt WE, Hess RM. Surgical risk as related to time of intervention in the repair of intracranial aneurysms. *J Neurosurg.* 1968;28(1):14-20.
- Report of World Federation of Neurological Surgeons Committee on a Universal Subarachnoid Hemorrhage Grading Scale. *J Neurosurg.* 1988;68(6):985-986.
- Dengler NF, Diesing D, Sarrafzadeh A, Wolf S, Vajkoczy P. The Barrow Neurological Institute Scale Revisited: Predictive Capabilities for Cerebral Infarction and Clinical Outcome in Patients With Aneurysmal Subarachnoid Hemorrhage. *Neurosurgery.* 2017;81(2):341-349.
- Weisscher N, Vermeulen M, Roos YB, de Haan RJ. What should be defined as good outcome in stroke trials; a modified Rankin score of 0-1 or 0-2? *J Neurol.* 2008;255(6):867-874.