

# The Prediction of 30-Day Mortality and Functional Outcome in Spontaneous Intracerebral Hemorrhage with Secondary Ventricular Hemorrhage: A Score Comparison

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**Abstract** The original ICH (oICH) score was tested in different populations and showed good accuracy in the prediction of outcome and 30-day mortality after spontaneous ICH. The oICH was developed to stratify patients with all types of spontaneous intracerebral hemorrhage (SICH). Several modifications of the oICH score exist in the literature.

In the current study, we tested the oICH score, two modified ICH scores, and the IVH score on a cohort of 171 patients with SICH and mandatory secondary intraventricular hemorrhage (IVH). Receiver-operating characteristic (ROC) curves were plotted, and the areas under the curves (AUC) were calculated for each score.

The calculated AUCs for the prediction of 30-day mortality in the cohort were 0.736, 0.816, 0.805, and 0.836 for the original ICH, the mICH-A, the mICH-B, and the new IVH score, respectively. The best AUC for functional outcome was observed for the mICH-B score (0.823). For the mICH-A and the IVH score, an AUC of 0.811 was calculated.

The scores that include the quantification of IVH or the grading of hydrocephalus show good accuracy in the prediction of 30-day mortality and functional outcome at 6 months in SICH with secondary IVH.

**Keywords** Intracerebral hemorrhage · Intraventricular hemorrhage · Hydrocephalus · ICH score

## Introduction

Several scores are known to predict survival and functional outcome in spontaneous intracerebral hemorrhage [2, 7, 9, 13, 15]. Currently, none of these scores has been established in clinical routine for risk stratification of SICH.

The first easy-to-use prediction score for SICH was introduced by Hemphill et al. in 2001 (oICH score) [9]. The oICH score was developed on the basis of independent predictors for 30-day mortality from a retrospective chart review. The score was tested on different populations and showed good predictive value for outcome and mortality [2, 3, 6, 7, 10]. In previous studies, SICH with secondary intraventricular hemorrhage (IVH) was associated with high 30-day mortality rates and unfavorable functional outcome [16].

In 2006, Godoy et al. [7] developed two scores in a modification of the oICH score and compared them with the oICH score. Both modified ICH scores (mICH-A and mICH-B) included the Graeb score, which stratified the intraventricular extension of a hemorrhage.

The role of hydrocephalus in the prediction of outcome is controversial. Hydrocephalus was found to be a predictor of 30-day mortality in some studies [4, 12]. Acute obstructive hydrocephalus in IVH should be treated by the insertion of an external ventricular drain (EVD) [1, 5]. However, up to now no randomized trial has shown a benefit after EVD implantation. The first score to include a categorization of hydrocephalus together with clinical parameters was the IVH score [14].

The aim of this study was to test the accuracy of the different scores on a large cohort of patients with SICH and secondary IVH.

## Materials and Methods

A total of 171 patients with the diagnosis of deep-seated intracerebral hematoma and secondary IVH were studied. All patients were admitted to the Department of Neurosurgery of the University Hospital Giessen.

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Inclusion criteria were the confirmation of SICH and secondary IVH by computerized tomography (CT) and patient age of 18–90 years.

All included patients received at least one external ventricular drain (EVD) to relieve obstructive hydrocephalus. All EVDs were placed in the first 24 h after ictus at our department after the initial CT scan had been reviewed.

Patients with traumatic hemorrhage, ischemic stroke, brain tumor, subarachnoid hemorrhage due to aneurysm or malformation, infratentorial origin of hemorrhage, SICH spreading into the brainstem, strict lobar hematoma, and therapeutic anticoagulation were excluded. Decompressive craniotomy and evacuation of the hematoma were also defined as exclusion criteria.

The first CT scan after ictus before EVD placement was reviewed. Hematoma volume was determined by the ABC/2 method [11]. IVH was graded according to the Graeb scale [8]. For the grading of hydrocephalus we used our own hydrocephalus grading system, which has been published elsewhere [14].

The following scores were compared: the original ICH score (oICH) [9], modified ICH-A and ICH-B score (mICH-A and mICH-B score) [7], and the IVH score. The components of the IVH score were published elsewhere [14].

To estimate the accuracy of each score, the area under the curve (AUC) was calculated using the receiver-operator-characteristic (ROC) method (Fig. 1).

Thirty-day mortality and functional outcome were determined 6 months after ictus.

Good functional outcome was defined as mRS  $\leq 3$  and bad functional outcome as mRS  $\geq 4$ .

All statistical analyses were computed with the SPSS System 17.0 for Windows (SPSS Inc., Chicago, IL).

## Results

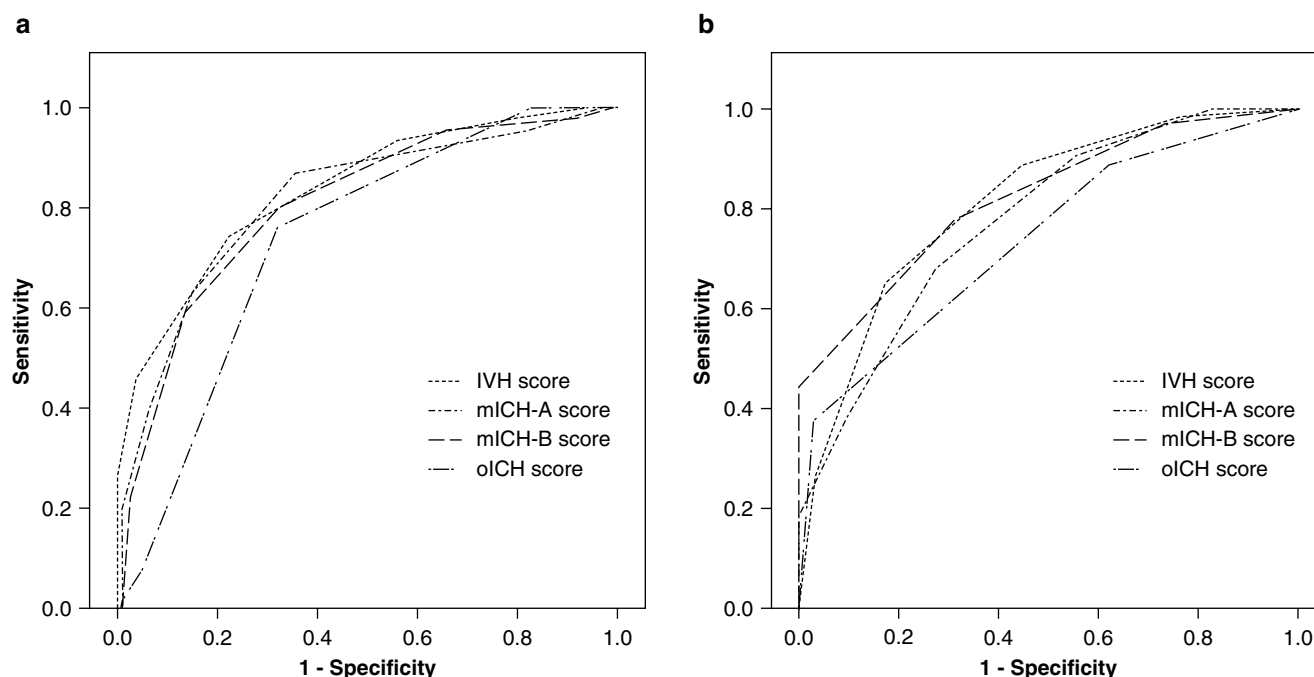
A total of 171 patients with deep-seated intracerebral hematoma and secondary IVH who were admitted to our department between January 1995 and July 2008 were reviewed. Ten patients were excluded because of missing follow-up or missing the initial CT scan.

The observed 30-day mortality was 28.6%. Six months after ictus, only 17.4% of the patients showed a favorable functional outcome (mRS  $\leq 3$ ).

The baseline characteristics of the cohort are presented in Table 1.

## Comparison of the Scores

The highest area under the curve (AUC) for predicting 30-day mortality was observed for the secondary IVH score at 0.836 (95% CI, 0.766–0.906), and for the mICH-A and the mICH-B score at 0.816 (95% CI, 0.740–0.892) and 0.805 (95% CI,



**Fig. 1** ROC curve analysis with AUC for 30-day mortality (**a**) and functional outcome (**b**)

**Table 1** Characteristics of 161 patients with secondary IVH

Age, years	36–86 (62.8±11.2)*
GCS	3–15 (8.7±3.3)*
Hematoma side <i>n</i> (%)	
Left	72 (44.7)
Right	89 (55.3)
Localization <i>n</i> (%)	
Puttinal	56 (34.8)
Thalamic	62 (38.5)
Caudate	23 (14.3)
Total basal ganglia	20 (12.4)
Volume of hematoma, cm <sup>3</sup>	0.5–118.7 (27.6±23.0)*
Hydrocephalus <i>n</i> (%)	93 (89.4)
Absent	13 (8.1)
Beginning	32 (19.9)
Moderate	84 (52.2)
Severe	32 (19.9)
Graeb score	2–12 (6.6±2.4)*

\*Mean±SD

0.729–880). The original ICH score showed the lowest accuracy with an AUC of 0.736 (95% CI, 0.656–0.816).

In predicting the functional outcome, the highest AUC was found for the mICH-B score with an AUC of 0.823 (95% CI, 0.740–0.907). The AUCs for the IVH score and mICH-A score were 0.811 (95% CI, 0.717–0.907) and 0.778 (95% CI, 0.677–0.878), respectively. For the oICH score an AUC of 0.738 (95% CI, 0.635–0.841) was observed.

## Discussion

The IVH and the mICH scores are comparable in predicting 30-day mortality. In the prediction of functional outcome, the mICH-B score followed by the IVH score reached the highest AUC. For the oICH score, only fair accuracy was calculated.

The IVH score [14] only includes components that can be identified easily during acute management in the emergency department and on the initial CT scan. The only additional score to determine is the GCS. The GCS is also part of the other tested scores.

The mICH score [7] includes the Graeb score [8] for quantifying blood in the ventricles. The mICH-A and mICH-B scores use different cut-off points for the Graeb score, GCS, and age.

The oICH score [9] contains the highest age cut-off with <80 and ≥80 years, and is the only score that includes one additional point for an infratentorial origin of hemorrhage.

The inclusion of variables like the Graeb score or hydrocephalus grading into an ICH scoring system improves the

prediction of 30-day mortality and functional outcome at 6 months in SICH with secondary IVH.

**Conflict of interest statement** We declare that we have no conflict of interest.

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