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The Analysis Study of Prognostic Tools for Prediction of Early Mortality in Hemorrhagic Stroke: A Comprehensive Systematic Review

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ABSTRACT

Background: Strokes are a major cause of mortality and morbidity worldwide. Spontaneous (nontraumatic) intracerebral hemorrhage (ICH) is an important cause of stroke, with an annual incidence of 24.6 per 100 000. Various prognostic scores have been developed to predict survival after ICH, but none are used routinely in clinical practice. They are different in the prognostic factors used, their complexity, as well as ease of use. There has been concern that predicting a poor outcome using these scores may lead to inappropriate withdrawal or limitation of care early after ICH, and thus, these predictions of poor outcome may become self-fulfilling prophecies. However, because ICH has a high 30-day mortality of about 40%. **The aim:** The aim of this study to show about prognostic tools for prediction early mortality in hemorrhagic stroke. **Methods:** By the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, this study was able to show that it met all of the requirements. This search approach, publications that came out between 2014 and 2024 were taken into account. Several different online reference sources, like Pubmed, SagePub, and Sciencedirect were used to do this. It was decided not to take into account review pieces, works that had already been published, or works that were only half done. **Result:** Eight publications were found to be directly related to our ongoing systematic examination after a rigorous three-level screening approach. Subsequently, a comprehensive analysis of the complete text was conducted, and additional scrutiny was given to these articles. **Conclusion:** ICH-GS as a prognostication tool in stroke patients instead of the widely used ICH score. Baseline medical problems, clinical severity, and basic laboratory tests available within the first 12 hours of admission provided strong independent predictors of in-hospital mortality in acute stroke patients.

Keyword: Hemorrhagic stroke, prognostic, mortality.

INTRODUCTION

Outcomes following a stroke event can range from full recovery, through varying degrees of disability to death. Given the subsequent need for intervention planning, resource use, and lifestyle adjustments, predicting outcome following stroke is of key interest and importance to patients, their families, clinicians, and hospital administrators. Various tools exist to assist in estimating stroke-related prognosis. For example, the ABCD2 score uses clinical features to predict risk of stroke following transient ischemic attack (TIA). Although there are criticisms of ABCD2, it is widely used and included in stroke guidelines. Scales for predicting acute stroke outcomes from baseline features are also described in the scientific literature. Often prognosis scales report mortality; however, given the disabling nature of stroke, scales predicting death and/or longer-term disability may be more useful in the stroke setting.[1]

Strokes are an important cause of mortality and morbidity worldwide. The consequences of stroke can be severe, leading annually to 5 million deaths and another 5 million people being left permanently disabled. While hemorrhagic stroke/intracerebral hemorrhage (ICH) is less common than ischemic stroke, the prognosis of ICH is substantially worse than those conditions with an ischemic etiology. The proportion of stroke patients with ICH was 14.5% in an Australian study, with a 28-day mortality of 45%, similar to data obtained in Europe and the US. The threat from ICH appears to be growing (perhaps due to an aging population), as indicated by a 47% increase in its incidence and a 20% increase in the number of deaths during 1990-2010 in the Global Burden Disease Study.[2]

Several studies in recent years have therefore focused on deriving and validating prognostic scores for detecting early mortality after an ICH in the acute setting. This is particularly pertinent given that the risk of a poor outcome is higher for ICH than for the other stroke subtypes, and the use of a prognostic model has been found to confer greater accuracy than merely relying on clinical judgment. In the absence of well-established interventions to reduce deaths from ICH, accurate prognostic tools may prove useful for informed decision-making in the acute phase of ICH, including the options of transferring to intensive care, rehabilitation, and palliation. In the research setting, prognostic scores may also prove useful for the risk stratification of participants in clinical trials of interventions for ICH.[2]

Hemorrhagic stroke is due to bleeding into the brain by the rupture of a blood vessel. Hemorrhagic stroke may be further subdivided into intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH). ICH is bleeding into the brain parenchyma, and SAH is bleeding into the subarachnoid space. Hemorrhagic stroke is associated with severe morbidity and high mortality. Progression of hemorrhagic stroke is associated with worse outcomes. Early diagnosis and treatment are essential given the usual rapid expansion of hemorrhage, causing sudden deterioration of consciousness and neurological dysfunction.[3,4]

METHODS

Protocol

By following the rules provided by Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, the author of this study made certain that it was up to par with the requirements. This is done to ensure that the conclusions drawn from the inquiry are accurate.

Criteria for Eligibility

For the purpose of this literature review, we compare and contrast prognostic tools for prediction early mortality in hemorrhagic stroke. It is possible to accomplish this by researching of the prognostic tools for prediction early mortality in hemorrhagic stroke. As the primary purpose of this piece of writing, demonstrating the relevance of the difficulties that have been identified will take place throughout its entirety.

In order for researchers to take part in the study, it was necessary for them to fulfil the following requirements: 1) The paper needs to be written in English, and it needs to determine about the prognostic tools for prediction early mortality in hemorrhagic stroke. In order for the manuscript to be considered for publication, it needs to meet both of these requirements. 2) The studied papers include several that were published after 2014, but before the time period that this systematic review deems to be relevant. Examples of studies that are not permitted include editorials, submissions that do not have a DOI, review articles that have already been published, and entries that are essentially identical to journal papers that have already been published.

Search Strategy

We used "prognostic tools for prediction early mortality in hemorrhagic stroke." as keywords. The search for studies to be included in the systematic review was carried out using the PubMed, SagePub, and Sciencedirect databases.

Table 1. Search Strategy

Database	**Search Strategy**	***Hits***
Pubmed	*(("*Hemorrhagic stroke*"[MeSH Subheading] OR "*Diagnostic*"[All Fields] OR "*Therapy*" [All Fields]) AND ("*Management*"[All Fields] OR "*Prognostic*"[All Fields]) AND ("*Tool*"[All Fields]) OR ("*Prediction*" [All Fields]))*	1729

Science Direct	*(("Hemorrhagic stroke"[MeSH Subheading] OR "Diagnostic"[All Fields] OR "Therapy" [All Fields]) AND ("Management"[All Fields] OR "Prognostic"[All Fields]) AND ("Tool"[All Fields]) OR ("Prediction" [All Fields]))*	1203
Sagepub	*(("Hemorrhagic stroke"[MeSH Subheading] OR "Diagnostic"[All Fields] OR "Therapy" [All Fields]) AND ("Management"[All Fields] OR "Prognostic"[All Fields]) AND ("Tool"[All Fields]) OR ("Prediction" [All Fields]))*	1264

Data retrieval

After reading the abstract and the title of each study, the writers performed an examination to determine whether or not the study satisfied the inclusion criteria. The writers then decided which previous research they wanted to utilise as sources for their article and selected those studies. After looking at a number of different research, which all seemed to point to the same trend, this conclusion was drawn. All submissions need to be written in English and cannot have been seen anywhere else.

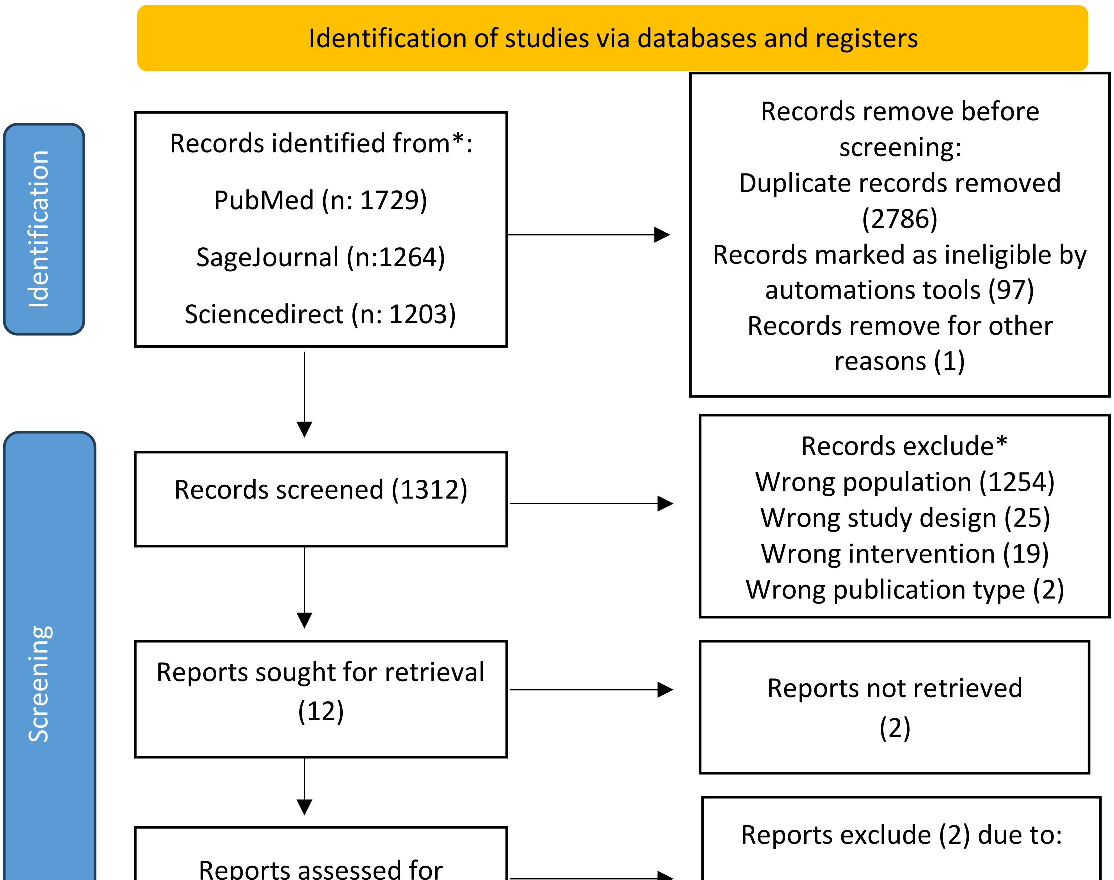

Figure 1. Article search flowchart

Only those papers that were able to satisfy all of the inclusion criteria were taken into consideration for the systematic review. This reduces the number of results to only those that are pertinent to the search. We do not take into consideration the conclusions of any study that does not satisfy our requirements. After this, the findings of the research will be analysed in great detail. The following pieces of information were uncovered as a result of the inquiry that was carried out for the purpose of this study: names, authors, publication dates, location, study activities, and parameters.

Quality Assessment and Data Synthesis

Each author did their own study on the research that was included in the publication's title and abstract before making a decision about which publications to explore further. The next step will be to evaluate all of the articles that are suitable for inclusion in the review because they match the criteria set forth for that purpose in the review. After that, we'll determine which articles to include in the review depending on the findings that we've uncovered. This criteria is utilised in the process of selecting papers for further assessment. in order to simplify the process as much as feasible when selecting papers to evaluate. Which earlier investigations were carried out, and what elements of those studies made it appropriate to include them in the review, are being discussed here.

Table 2. Critical appraisal of Study

Parameters	(Han, JX et al., 2017)	(Bautista, AF et al., 2019)	(Houben, R et al., 2018)	(Mao, B et al., 2024)	(Du, W et al., 2020)	(Abujaber, AA et al., 2024)	(Jouybari, MF et al., 2021)	(Muresan, EM et al., 2022)
1. Bias related to temporal precedence								
Is it clear in the study what is the “cause” and what is the “effect” (ie, there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Bias related to selection and allocation								
Was there a control group?	No	No	No	No	No	No	No	No
3. Bias related to confounding factors								
Were participants included in any comparisons similar?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Bias related to administration of intervention/exposure								
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	No	No	No	No	No	No	No	No
5. Bias related to assessment, detection, and measurement of the outcome								
Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	No	No	No	No	No	No	No	No
Were the outcomes of participants included in any comparisons measured in the same way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Bias related to								

participant retention								
Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Statistical conclusion validity								
Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

RESULT

Using reputable resources like Science Direct, PubMed, and SagePub, our research team first gathered 4196 publications. A thorough three-level screening strategy was used to identify only eight papers as directly relevant to our ongoing systematic evaluation. Next, a thorough study of the entire text and further examination of these articles were selected. Table 1 compiles the literature that was analyzed for this analysis in order to make it easier to view.

Table 1. The litelature include in this study

Author	Origin	Method	Sample	Result
Han, JX et al., 2018[5]	Singapore	We reviewed 1338 patients with spontaneous ICH consecutively admitted to the National Neuroscience Institute (NNI), Singapore, between January 2009 and	1338	All three models showed good calibration and both the Hosmer-Lemeshow and the le Cessie-van Houwelingen-Copas goodness-of-fit test showed p values >0.05. AUCs ranged from 0.86 to 0.90 indicating good discriminative ability, with the ICH-GS performing the best with the highest AUC, lowest AIC (849), and overall

		November 2013.		highest net benefit in the DCA.
Bautista, AF et al., 2019[6]	USA	Retrospective observational cohort study.	707	Due to updated guidelines in 2013, we revalidated our model (2016–2017). The final model included stroke type (intracerebral hemorrhage vs ischemic stroke: odds ratio [95% CI] of 0.92 [0.50–1.68] and subarachnoid hemorrhage vs ischemic stroke: 1.0 [0.40–2.49]), year (1.01 [0.66–1.53]), age (1.78 [1.20–2.65] per 10 yr), smoking (8.0 [2.4–26.7]), mean arterial pressure less than 60 mm Hg (3.08 [1.67–5.67]), Glasgow Coma Scale (0.73 [0.66–0.80] per 1 point increment), WBC less than 11 K (0.31 [0.16–0.60]), creatinine (1.76 [1.17–2.64] for 2 vs 1), congestive heart failure (2.49 [1.06–5.82]), and warfarin (2.29 [1.17–4.47]). In summary, age, smoking, congestive heart failure, warfarin use, Glasgow Coma Scale, mean arterial pressure less than 60 mm Hg, admission WBC, and creatinine levels were independently associated with mortality in our training cohort. The model had internal area under the curve of 0.83 (0.79–0.89) after adjustment for over-fitting, indicating excellent discrimination. When applied to the test

				data from 2010 to 2012, the nomogram accurately predicted mortality with area under the curve of 0.79 (0.71–0.87) and scaled Brier's score of 0.17. Revalidation of the same model in the recent dataset from 2016 to 2017 confirmed accurate prediction with area under the curve of 0.83 (0.75–0.91) and scaled Brier's score of 0.27.
Houben, R et al., 2018[7]	Netherlands	We retrospectively selected all consecutive adult non-traumatic ICH cases (three hospitals, region South-Limburg, the Netherlands 2004–2009). Mortality at 30 days was recorded. Using univariable and multivariable logistic regression, association between OAC use and 30-day mortality was tested.	1232	We analyzed 1,232 cases, 282 (22.9%) were OAC related ICH. Overall, 30-day mortality was 39.3%. OAC use was independently associated with 30-day mortality (OR 2.09, 95% CI, 1.48–2.95; $p < 0.001$), corrected for the five predictors of the ICH score. The ICH score performed slightly better in non-OAC-ICH (AUC 0.840) than in OAC-ICH (AUC 0.816), but this difference was not significant ($p = 0.39$). The ICH score and the New ICH score were both significantly correlated with 30-day mortality (rho 0.58, $p < 0.001$ and 0.59, $p < 0.001$, respectively). The AUC for the ICH score was 0.837, for New ICH score 0.840. This difference was not significant.
Mao, B et al., 2024[8]	China	We did a retrospective	1596	To facilitate accessibility, we also created a visual

		study in our study and identified cases of sICH from the MIMIC IV (n = 1486) and Zhejiang Hospital databases (n = 110).		online calculation page for the model. The XGBoost exhibited high accuracy in both internal validation (AUC = 0.907) and external validation (AUC = 0.787) sets. Calibration curve and decision curve analyses showed that the model had no significant bias as well as being useful for supporting clinical decisions. XGBoost is an effective algorithm for predicting in-hospital mortality in patients with sICH, indicating its potential significance in the development of early warning systems.
Du, W et al., 2020[9]	China	We analyzed data found in the China National Stroke Registry (CNSR) of 2,453 hospitalized patients in 132 urban Chinese hospitals, diagnosed with ICH from September 2007 to August 2008. The outcomes analysis included 30-day mortality,	22216	We found that the 30-day mortality was 12.6%, the frequency of a mRS 5–6 at discharge was 20.6%, and 1-year mortality was 21.9%. The PLAN score had good predictive value in 30-day mortality (C statistic, 0.82), death or severe dependence at discharge (0.84), and 1-year mortality (0.82).

		modified Rankin Scale score (mRS) of 5–6 at discharge, and 1-year mortality.		
Abujaber, AA et al., 2024[10]	Qatar	Data from the National Multiethnic Stroke Registry was utilized. Eight machine learning (ML) models were trained and evaluated using various metrics. SHapley Additive exPlanations (SHAP) analysis was used to identify the influential predictors.	9840	The final analysis included 9840 patients diagnosed with stroke were included in the study. The XGBoost algorithm exhibited optimal performance with high accuracy (94.5%) and AUC (87.3%). Core predictors encompassed National Institutes of Health Stroke Scale (NIHSS) at admission, age, hospital length of stay, mode of arrival, heart rate, and blood pressure. Increased NIHSS, age, and longer stay correlated with higher mortality. Ambulance arrival and lower diastolic blood pressure and lower body mass index predicted poorer outcomes.
Jouybari, MF et al., 2021[11]	Iran	In this prospective descriptive study, 100 patients with non-traumatic ICH were included. Clinical and radiographic data were collected and extent of	100	32 of 100 cases died at hospital and 6 more expired during 3-month follow-up. Risk factors of in-hospital mortality were warfarin use, surgical intervention, and high ICH score. Functional status of patients significantly improved 3 months after discharge. Factors associated with poor recovery were age older than 70, history of

		disability was measured by modified Rankin Scale (mRS) at discharge, 1 week, 1 month, and 3 months after discharge.		coronary artery disease (CAD), low Glasgow Coma Scale (GCS) at admission, elevated mean arterial pressure (MAP), longer hospitalization, and high ICH score.
Muresan, EM et al., 2022[12]	Romania	Demographic data, medical history and admission clinical parameters from adult patients with imaging-based sICH diagnosis were collected retrospectively, upon their ED presentation over a period of 18 months.	219	Of the 219 included patients, mortality rates reached 30.14% on day 7 and 46.12% at discharge. In the univariate analysis, day 7 mortality was significantly associated with history of diabetes, atrial fibrillation, ongoing anticoagulant treatment, the need of endotracheal intubation and ED cardiopulmonary resuscitation, and the presence of intraventricular hemorrhage and mass effect on the initial CT scan. White blood cells and granulocytes (but not the neutrophil-to-lymphocytes ratio, nor the CRP) were significantly higher in the deceased groups, alongside serum glucose. Derived inflammatory indexes were not significantly correlated with mortality endpoints. Cut-off values of 9.6×10^9/l for granulocytes and 132 mg/dl for glucose were identified as day 7 mortality predictors.

DISCUSSION

Intracerebral hemorrhage (ICH) is a major cause of death and disability, with an incidence rate of 24.6 per 100,000 person-years and a fatality rate of 40%. After such event, only 12–39% of patients regain independence. Contrary to ischemic stroke, medical care for ICH remains mostly supportive, and few interventions clearly demonstrated benefit in this population. Several prognostic tools have been proposed for mortality and functional outcome prediction in ICH. These tools are potentially useful for ascertaining prognosis, facilitating communication between clinicians, characterizing and selecting patients for interventions, and for benchmarking purposes in healthcare delivery. The aim of this study was to systematically identify, assess and review the methodological conduct and reporting of studies deriving prognostic tools for the risk of death and/or functional recovery after ICH and to evaluate their overall discrimination according to the method of derivation and type of outcome.[13–15]

The complications of intracerebral hemorrhage (ICH) are among the major predictors of early mortality and poor outcomes. Specialized neurocritical centers play a crucial role in providing medical care and improving patients' outcomes. Non-contrast computed tomography is the gold standard brain imaging study for the initial assessment of patients with acute stroke due to its availability and high sensitivity for detecting ICH. It helps to detect the hematoma location, size, and associated IVH and hydrocephalus. These characteristics of a hematoma act as predictors of patients' outcomes. Due to the high morbidity and mortality rates associated with ICH, early detection of high-risk patients would be helpful in early management.[16–18]

Stroke is the second leading cause of death and disability worldwide, with intracerebral hemorrhage (ICH) accounting for approximately 10% of all strokes and having an incidence of 24.6 per 100,000 person-years. Although the worldwide incidence of ICH and its associated morbidity and mortality have remained stable or decreased since the 1970s, definitive therapeutic options remain uncertain at this time, and there is evidence that in the United States, incidence rates have actually been rising. In an absolute sense, ICH still remains associated with high mortality and poor functional outcome.[19,20]

Previous studies have developed some predictive models for the short-term prognosis of patients with sICH using an imaging histology approach, which has high predictive efficacy but is not amenable to clinical practice. Furthermore, numerous studies fail to conduct external validation of their models, thereby constraining the model's generalizability and its broader applicability. Meanwhile, the vast majority of studies have only conducted model training and testing for machine learning by dividing the dataset randomly at one time, which increases the selection bias of the dataset and ultimately leads to unstable or even inaccurate performance of the model. Other studies, despite constructing predictive models, have not grounded them in a platform for feasible use, thereby curtailing their clinical utility.[21–23]

Guidelines recommend the use of grading scales in ICH patients as a part of the initial evaluation for the purposes of helping to streamline assessment and facilitating communication between providers (4). Grading scales can be characterized using two distinct but equally important properties: discrimination and calibration (6). Discrimination refers to the ability of a prognostic tool to differentiate patients in a sample of a population who will suffer the outcome of interest from those who will not and can be evaluated using the C-statistic or area under the receiver operating characteristic curve. Calibration refers to the ability of the same tool to accurately predict in a sample population the proportion of patients who will suffer the same outcome.[24,25]

CONCLUSION

In conclusion, ICH-GS as a prognostication tool in stroke patients instead of the widely used ICH score. Baseline medical problems, clinical severity, and basic laboratory tests available within the first 12 hours of admission provided strong independent predictors of in-hospital mortality in acute stroke patients.

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