

Possibilities of clinical neuroimaging assessment scales using for patient severity in the onset of cerebral hemorrhagic supratentorial stroke to predict the outcome of the disease acute period

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The main purpose of the study was to determine the criteria for the vital and functional prognosis of the cerebral hemorrhagic supratentorial stroke (CHSS) acute period outcome based on the Hemphill Intracerebral Hemorrhage (Hemphill-ICH) Scale and ICH-Grading Scale (ICH-GS) in the onset of the disease.

Materials and methods. A prospective, cohort, complex clinical and paraclinical study was conducted in 124 patients (72 men and 52 women, mean age 64.7 ± 1.1 years) with CHSS. This study included clinical assessment using National Institute of Health Stroke Scale and Glasgow Coma Scale, visualization of cerebral structures and integrated assessment of health state severity using the Hemphill-ICH Scale and ICH-GS. The functional outcome of the acute period was determined by the modified Rankin Scale.

Results. The Hemphill-ICH Scale score ≥ 2 and ICH-GS score ≥ 8 are associated with an increased risk of CHSS acute period lethal outcome, at 7.1 [2.8–18.0] ($P < 0.01$) and 4.4 [2.2–9.3] times ($P < 0.01$), respectively. The Hemphill-ICH Scale is characterized by a higher informative value for CHSS acute period lethal outcome prediction (AUC = 0.84) in comparison with the ICH-GS (AUC = 0.78, $P < 0.05$). The ICH-GS is characterized by a higher informative value for the functional prognosis of CHSS acute period outcome (AUC = 0.69) in comparison with the Hemphill-ICH Scale (AUC = 0.61, $P < 0.05$).

Conclusions. Predictors of CHSS acute period lethal outcome are Hemphill-ICH Scale score ≥ 2 and ICH-GS score ≥ 8 . The Hemphill-ICH Scale score = 0 and ICH-GS score = 5 are the criteria for the favourable functional outcome of CHSS acute period (mRS score ≤ 3 on the 21st day). The informative value of the Hemphill-ICH Scale and ICH-GS is higher for the vital prognosis than for the functional prognosis of CHSS acute period outcome verification.

Key words:

cerebral hemorrhage, X-Ray tomography, prognosis.

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Можливості застосування шкал клініко-нейровізуалізаційного оцінювання ступеня тяжкості пацієнтів у дебюті мозкового геморагічного супратенторіального інсульту для прогнозування виходу гострого періоду захворювання

A. A. Кузнєцов

Мета роботи – визначення критеріїв вітального та функціонального прогнозу виходу гострого періоду мозкового геморагічного супратенторіального інсульту (МГСІ) на підставі оцінювання за шкалами Hemphill Intracerebral Hemorrhage (Hemphill-ICH) та ICH Grading Scale (ICH-GS) у дебюті захворювання.

Матеріали та методи. Здійснили проспективне, когортне, комплексне клініко-параклінічне дослідження 124 пацієнтів (72 чоловіки та 52 жінки, середній вік – $64,7 \pm 1,1$ року) з МГСІ, що включало оцінювання за шкалою інсульту Національного інституту здоров'я США, шкалою коми Глазго, візуалізацію церебральних структур, інтегральне оцінювання тяжкості з застосуванням шкал Hemphill-ICH та ICH-GS. Функціональний вихід гострого періоду захворювання визначали за модифікованою шкалою Ренкіна (мШР).

Результати. Значення сумарного бала ≥ 2 за шкалою Hemphill-ICH та ≥ 8 по ICH-GS асоційовані з підвищенням ризику летального результату відповідно в 7,1 [2,8–18,0] ($p < 0,01$) і 4,4 [2,2–9,3] рази ($p < 0,01$). Шкала Hemphill-ICH характеризується вищою інформативністю для прогнозування вітального прогнозу виходу гострого періоду МГСІ (AUC = 0,84) порівняно зі шкалою ICH-GS (AUC = 0,78, $p < 0,05$). Шкала Hemphill-ICH поступається ICH-GS за прогностичною цінністю для визначення ступеня функціонального відновлення на 21 добу МГСІ (AUC 0,61 проти 0,69, $p < 0,05$).

Висновки. Предикторами летального виходу гострого періоду МГСІ є значення сумарного бала ≥ 2 за шкалою Hemphill-ICH і ≥ 8 по ICH-GS. Критеріями сприятливого функціонального виходу гострого періоду МГСІ є значення 0 балів за шкалою Hemphill-ICH і 5 балів за ICH-GS (значення ≤ 3 бали за мШР на 21 добу захворювання). Інформативність шкал Hemphill-ICH та ICH-GS для визначення вітального прогнозу перевершує таку для верифікації функціонального прогнозу виходу гострого періоду МГСІ.

Ключові слова:

внутрішньо-мозковий крововилив, комп'ютерна томографія, прогноз.

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Возможности использования шкал клиничко-нейровизуализационной оценки степени тяжести пациентов в дебюте мозгового геморагического супратенториального инсульта для прогнозирования исхода острого периода заболевания

A. A. Кузнєцов

Цель работы – определить критерии витального и функционального прогноза исхода острого периода мозгового геморагического супратенториального инсульта (МГСИ) на основании оценки по шкалам Hemphill Intracerebral Hemorrhage (Hemphill-ICH) и ICH Grading Scale (ICH-GS) в дебюте заболевания.

Ключевые слова:

внутричерепное кровоизлияние, компьютерная томография, прогноз.

Материалы и методы. Проведено проспективное, когортное, комплексное клинично-параклиническое исследование 124 пациентов (72 мужчины и 52 женщины, средний возраст $64,7 \pm 1,1$ года) с МГСИ, которое включало оценку по шкале инсульта Национального института здоровья США, шкале комы Глазго, визуализацию церебральных структур, интегральную оценку тяжести с использованием шкал Hemphill-ICH и ICH-GS. Функциональный исход острого периода заболевания определялся по модифицированной шкале Рэнкина (мШР).

Результаты. Значения суммарного балла ≥ 2 по шкале Hemphill-ICH и ≥ 8 по ICH-GS ассоциированы с повышением риска летального исхода соответственно в 7,1 [2,8–18,0] ($p < 0,01$) и 4,4 [2,2–9,3] раза ($p < 0,01$). Шкала Hemphill-ICH характеризуется более высокой информативностью для прогнозирования витального прогноза исхода острого периода МГСИ (AUC = 0,84) в сравнении со шкалой ICH-GS (AUC = 0,78, $p < 0,05$). Шкала Hemphill-ICH уступает ICH-GS по предсказывающей ценности для определения степени функционального восстановления на 21 сутки МГСИ (AUC 0,61 против 0,69, $p < 0,05$).

Выводы. Предикторами летального исхода острого периода МГСИ выступают значения суммарного балла ≥ 2 по шкале Hemphill-ICH и ≥ 8 по ICH-GS. Критериями благоприятного функционального исхода острого периода МГСИ выступают значения 0 баллов по шкале Hemphill-ICH и 5 баллов по ICH-GS (значение ≤ 3 балла по мШР на 21 сутки заболевания). Информативность шкал Hemphill-ICH и ICH-GS для определения витального прогноза превосходит таковую для верификации функционального прогноза исхода острого периода МГСИ.

Introduction

Cerebral hemorrhagic stroke (CHS) is at leading positions as for the structure of death and disability causes in young and middle-aged people in most countries of the world [2,6,12]. The most common focus of intracerebral haemorrhages is the supratentorial localization [13,15].

One of the ways to improve the effectiveness of treatment activities in this contingent of patients is a differentiated definition of optimal therapeutic tactics with regard to individual vital and functional prognosis of the disease acute period outcome [4,5,10].

Numerous studies have convincingly proved the connexion between the initial neurological deficiency level, structural changes in brain substance and the outcome of cerebral hemorrhagic supratentorial stroke (CHSS), which justifies the advisability of complex clinical-neuroimaging scales using in assessment of patient severity for verifying the prognosis [3,7,8,11,14]. In accordance with the results of the meta-analysis, the Hemphill Intracerebral Hemorrhage (Hemphill-ICH) Scale and ICH-Grading Scale (ICH-GS) are the most informative for the prediction of patient survival during the first half of the year after CHS [9].

However, unified criteria for the CHSS acute period outcome prediction along with the optimal sensitivity (Se) and specificity (Sp) ratio, which would take into account the results of the assessment on the indicated scales, are currently unavailable.

The aforesaid served a thematic justification of this study.

Purpose

The main purpose of the study was to determine the criteria for the vital and functional prognosis of the acute period outcome of cerebral hemorrhagic supratentorial stroke based on the Hemphill-ICH Scale and ICH-GS in the onset of the disease.

Materials and methods

To achieve the goal, a prospective, cohort, complex clinical and paraclinical study was conducted in 124 patients (72 men and 52 women, mean age 64.7 ± 1.1 years) with CHSS. They were treated at Cerebrovascular Accident

Department of the Municipal Institution "Zaporizhzhia City Clinical Hospital No. 6".

Inclusion criteria were:

- 1) spontaneous supratentorial intracerebral hemorrhage confirmed by the clinical computed tomography study;
- 2) hospitalization within the first 24 hours since the onset of the disease;
- 3) a signed informed consent form for the participation in the study;

Exclusion criteria were:

- 1) presence of acute disorders of cerebral circulation in the anamnesis;
- 2) primary subarachnoid and / or intramuscular hemorrhage;
- 3) ≥ 2 lesions;
- 4) the presence of indications for surgical treatment upon the examination held by a neurosurgeon;
- 5) the presence of oncologic pathology in the medical history;
- 6) decompensated stage of somatic pathology;
- 7) extracerebral cause of death in accordance with the autopsy results.

All patients underwent clinical neurological examination along with the initial levels of neurologic deficits assessment in accordance with the National Institute of Health Stroke Scale and cerebral syndrome assessment in accordance with the Glasgow Coma Scale. The functional outcome of the acute period was determined by the modified Rankin Scale. The value of 4–5 points were considered as unfavourable functional outcome of CHSS acute period, and ≤ 3 points on the 21st day of the disease were considered as favourable.

The visualization of cerebral structures was carried out with the help of Computed Tomography Scanner «Siemens Somatom Spirit» within the first 24 hours since the onset of the disease, taking into consideration the lesion size (LS), the severity of dislocation syndrome due to the median brain structures displacement, the presence of blood breakthrough into the ventricular system of the brain. The LS was calculated in accordance with the ellipsoid formula: $LS (ml) = a * b * c/2$, where a, b, c are linear dimensions of the lesion (cm).

The Hemphill-ICH Scale and ICH-GS were used for the integrated assessment of health state severity in patients with cerebral hemorrhagic supratentorial stroke. They take

into account different age gradations, the severity of brain syndrome in accordance with the Glasgow Coma Scale upon hospitalization LS and localization and the presence of blood breakthrough into the ventricular system of the brain.

All patients underwent conservative therapy in accordance with the Unified Clinical Protocol for the provision of medical care to patients with cerebral hemorrhagic stroke, approved by the order of the Ministry of Health of Ukraine No. 275, dated April 17, 2014 [1]. The statistical data processing was carried out with the help of Statistica 6.0 software (StatSoft Inc., USA, series number AXXR712D833214FAN5) and MedCalc software (version 16.4). Descriptive statistics were presented in the form of the mean value and the standard error of the mean value ($M \pm m$). Receiver operating characteristic (ROC) analysis and relative risk (RR) calculation were used for the determination of predictive criteria.

Results and discussion

Clinical and neuroimaging characteristics of examined patients in the onset of the disease are presented in the *Table 1*.

Lethal outcome (12.1 %), relatively unfavourable functional outcome in the form of 4–5 points on the Rankin Scale (37.9 %) and relatively favourable functional outcome in the form of ≤ 3 points on the aforementioned scale (50.0 %) were registered in the outcome structure in the acute period of the disease.

In accordance with the ROC analysis, it has been established that the predictors of disease acute period lethal outcome are the Hemphill-ICH Scale score ≥ 2 (Se = 77.3 %, Sp = 77.5 %) and ICH-GS score ≥ 8 (Se = 54.6 %, Sp = 86.3 %).

The frequency distribution of CHSS acute period lethal outcome in terms of the Hemphill-ICH Scale and ICH-GS is shown in the *Table 2*.

As a result, the Hemphill-ICH Scale score ≥ 2 and ICH-GS score ≥ 8 are associated with an increased risk of the CHSS acute period lethal outcome, by 7.1 [2.8–18.0] ($P < 0.01$) and 4.4 [2.2–9.3] times ($P < 0.01$), respectively.

It has been determined that the Hemphill-ICH Scale is characterized by a higher informative value for the vital prognosis of CHSS acute period (AUC = 0.84) in comparison with the ICH-GS (AUC = 0.78, $P < 0.05$).

The Hemphill-ICH Scale score = 0 (Se = 79.6 %, Sp = 28.3 %, AUC = 0.61) and ICH-GS score = 5 (Se = 59.2 %, Sp = 71.7 %, AUC = 0.69) are criteria for a favourable functional outcome of the acute period.

Criteria for prognosis of CHSS acute period outcome, based on the assessment of patients in the onset of the disease in accordance with the Hemphill-ICH scale and ICH-GS, are integrated in the *Table 3*.

It has been determined that the Hemphill-ICH Scale is inferior to ICH-GS as for the predictive value related to functional recovery degree determination upon the 21st day after CHSS (AUC 0.61 vs. 0.69, $P < 0.05$).

The comparative analysis of AUC values allows to state that the Hemphill-ICH Scale and ICH-GS are more informative for vital, rather than functional, prognosis of CHSS acute period outcome (AUC = 0.84 vs AUC = 0.61 for Hemphill-ICH Scale, $P < 0.05$; AUC = 0.78 vs AUC = 0.69 for ICH-GS, $P < 0.05$).

Table 1. Clinical and neuroimaging characteristics of examined patients in the onset of the disease, ($M \pm m$)

Data, units	Value
NIHSS score	12.1 \pm 0.6
GCS score	13.0 \pm 0.3
Hemphill-ICH Scale score	1.3 \pm 0.1
ICH-GS score	6.67 \pm 0.16
Lesion size, mL	22.9 \pm 2.3
Septum pellucidum displacement, mm	3.2 \pm 0.3
Pineal gland displacement, mm	2.6 \pm 0.3

Table 2. Frequency distribution of CHSS acute period lethal outcome in terms of the Hemphill-ICH score and ICH-GS

Scale	Value	Number of patients	Lethal outcome of the acute CHSS period (%)
Hemphill-ICH	≥ 2	40	42.5
	< 2	84	6.0
ICH-GS	≥ 8	26	46.2
	< 8	98	10.2

Table 3. Criteria for prognosis of CHSS acute period outcome

CHSS Acute Period Outcome	Predictors (scale, score)	
	Hemphill-ICH	ICH-GS
Lethal outcome	2–6	8–13
Unfavourable functional outcome (mRS score 4–5 on the 21st day)	1	6–7
Favourable functional outcome (mRS score ≤ 3 on the 21st day)	0	5

Table 4. Quality assessment of obtained criteria for vital and functional prognosis of CHSS acute period outcome in accordance with M. H. Zweig, G. Campbell Scale (1993)

Type of Prognosis	Scale	AUC	Quality grade in accordance with M. H. Zweig, G. Campbell Scale (1993)
Vital	Hemphill-ICH	0.84	Very Good
Vital	ICH-GS	0.78	Good
Functional	Hemphill-ICH	0.61	Average
Functional	ICH-GS	0.69	Average

The results of the obtained criteria quality assessment for vital and functional prognosis of CHSS acute period outcome in accordance with M. H. Zweig, G. Campbell Scale (1993) [16], which takes into account the AUC value, are shown in the *Table 4*.

Thus, the study made it possible to develop informative criteria for the short-term vital and functional prognosis of CHSS acute period outcome with the optimal sensitivity and specificity ratio in accordance with the Hemphill-ICH scale and ICH-GS. At the same time, the results of the analysis of AUC indicators based on these scales justify the advisability of the more informative criteria elaboration for predicting vital and, in particular, functional outcome of CHSS acute period.

Conclusions

1. Predictors of the lethal outcome of CHSS acute period are the Hemphill-ICH Scale score ≥ 2 (Se = 77.3 %, Sp = 77.5 %, RR = 7.1 [2.8–18.0], $P < 0.01$) and ICH-GS

score ≥ 8 (Se = 54.6 %, Sp = 86.3 %, RR = 4.4 [2.2–9.3] times, $P < 0.01$).

2. The Hemphill-ICH Scale score = 0 (Se = 79.6 %, Sp = 28.3 %) and the ICH-GS score = 5 (Se = 59.2 %, Sp = 71.7 %) are the criteria for the favourable functional outcome of CHSS acute period (mRS score ≤ 3 on the 21st day).

3. The Hemphill-ICH Scale is characterized by a higher informative value for CHSS acute period lethal outcome prediction (AUC = 0.84) in comparison with the ICH-GS (AUC = 0.78, $P < 0.05$).

4. The ICH-GS is characterized by a higher informative value for the functional prognosis of CHSS acute period outcome (AUC = 0.69) in comparison with the Hemphill-ICH Scale (AUC = 0.61, $P < 0.05$).

5. The informative value of the Hemphill-ICH Scale and ICH-GS is higher for the vital prognosis than for the verification of the functional prognosis of CHSS acute period outcome.

The perspective for the further scientific research is the elaboration of mathematical models for the CHSS acute period outcome prediction, which take into account complex results of clinical and neurovisual research at onset of disease.

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