Review of CHESS Score in SAH Patients in Local Malaysian Population

Sze-Voon Yee[1,2]   Abdul Rahman Ghani[1]   Azman Raffiq[2]

[1]Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia
[2]Department of Neurosurgery, Hospital Kuala Lumpur, Kuala Lumpur, Malaysia

Address for correspondence Sze-Voon Yee, MS, Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kelantan, 50586, Malaysia (e-mail: yeeszevoon@gmail.com).

Abstract

Background Chronic hydrocephalus caused by subarachnoid hemorrhage is a reversible and treatable condition. To date, existing clinical scores for predicting the development of posthemorrhagic hydrocephalus are few and difficult to apply in the clinical settings. Chronic hydrocephalus ensuing subarachnoid hemorrhage score (CHESS) was first published in 2016. Although it showed promising results, no external validation has been done outside Europe. We designed this study to validate the accuracy and reliability of CHESS score and to also look for other factors that may cause posthemorrhagic shunt dependent hydrocephalus.

Objectives   This study is to determine the reliability of CHESS score and to look for other parameters with predictive value in patients with shunt-dependent posthemorrhagic hydrocephalus.

Results Thirty-one percent of the studied population developed shunt-dependent hydrocephalus ($n = 41$). CHESS score showed an odds ratio (OR) of 2.184 with p-value < 0.001 and two other risk factors were found to be strongly related to develop shunt-dependent hydrocephalus, that is, early infarct in computed tomography (CT) brain (OR = 0.182; p-value = 0.004) and Fisher's grade > 3 (OR = 1.986; p-value = 0.047). The sensitivity and specificity for CHESS score in this cohort population showed a sensitivity of 73.2% and specificity of 93.3%. The area under the curve for CHESS score in our cohort is 0.922.

Conclusion   CHESS score is a reliable tool in early prediction of shunt-dependent hydrocephalus post subarachnoid hemorrhage.

Keywords
► shunt-dependent hydrocephalus
► posthemorrhagic hydrocephalus
► CHESS
► hydrocephalus risk factors
► aneurysmal subarachnoid hemorrhage

Introduction

Posthemorrhagic hydrocephalus (PHH) is a very common complication of aneurysmal subarachnoid hemorrhage (SAH). PHH develops following accumulation of blood in the subarachnoid space disrupting cerebrospinal fluid (CSF) hydrodynamics that may persist up to 50 days after the bleeding event[1] and contribute to prolonged morbidity in patients. Temporary diversion of CSF is a commonplace in such patients with a frequency of 15 to 87%,[1,2] and approximately 31% patients will eventually require a permanent shunt.[1]

Several studies[2-5] have attempted to look at the risk factors and ranked them accordingly into a usable scoring system to predict shunt dependency on post-SAH. However, none of the scoring systems succeeded in creating one good clinical usable scoring system until chronic hydrocephalus ensuing subarachnoid hemorrhage score (CHESS) was created by Jabbarli et al.[1] The CHESS score positive and negative predictive values for this scoring system were shown to be more accurate than the Dorai score, Fisher's score, and Hunt and Hess grading in predicting shunt-dependent hydrocephalus.[1] CHESS score has yet to gain clinical acceptance worldwide despite of its prediction accuracy because it still lacked of an

external validation despite its proven accuracy statistically. Therefore, the aim of this study is to study the reliability of CHESS score in predicting shunt-dependent PHH and also to look for other parameters that have strong correlation in development of shunt-dependent PHH.

Materials and Methods

Research Design

This is a retrospective study. Approval was obtained from the Medical Research and Ethics Committee of the Ministry of Health Malaysia and registered in the national register for clinical trials, registration ID: NMRR-16–2752–32572. The study aims to determine whether the CHESS score is a reliable tool to predict shunt-dependent PHH and also to look for any other parameters that have shown strong value in predicting shunt-dependent PHH.

Research Location and Duration

Data from patients who fulfilled the inclusion criteria from the two of the largest tertiary institutions in Malaysia, that is, Hospital Kuala Lumpur (HKL) and Hospital Queen Elizabeth (HQE),[6] and treated for aneurysmal SAH during the period of January 2014 to December 2016, were obtained and analyzed. The inclusion criteria included the following: (1) patients of all ages who were admitted for the first presentation of spontaneous nontraumatic SAH, (2) admission and treatment of the ruptured aneurysm of patients after the bleeding event, and (3) survival up to the 60 days (median period for shunt) of patients from initial presentation. The exclusion criteria were as follows: (1) demise of patients during admission and treatment of the ruptured aneurysm, (2) patients who were admitted for traumatic SAH, (3) patients who were admitted for recurrent SAH, and (4) demise of patients before the median period for shunt (<60 days).

Study Population

All patients who developed SAH, who were admitted to HKL and HQE, and who fulfilled the inclusion and exclusion criteria, were included in the study. The inclusion criteria for patients in this study were patients who were admitted and treated for the first presentation of aneurysmal bleed and patients who survived for up to 60 days from the initial ictus event. Patients who died during admission and treatment of ruptured aneurysm within the 60 days of median period, SAH secondary to trauma and recurrent nontraumatic SAH, were excluded from the study. Following the data from the original study, the median shunt rate for PHH is at 54 days,[1] therefore the 60-day period of follow-up was used in this study.

Method of Research

After the selection of patients, CHESS score and other parameters which are recorded are shown in ►Table 1. The parts of CHESS score include Hunt and Hess score of more or equal to 4 are as follows: location of ruptured aneurysm (posterior circulation), acute PHH requiring CSF diversion, intraventricular hemorrhage, and early cerebral infarction on CT scan.[1] The Hunt and Hess grading was collected by

reviewing patients' clinical data on the admission clerking, location of the aneurysm was confirmed by the cerebral angiogram, acute PHH requiring CSF diversion was determined based on the CT brain, and external ventricular drain was inserted for the patient. Intraventricular hemorrhage and early cerebral infarction (within 24 hours postaneurysm treatment) were determined on the CT scans. The CHESS for each patient was recorded solely by principal investigator.

Statistical Analysis

The recorded data were analyzed using the SPSS (version 22, SPSS Inc., IBM, Chicago, Illinois, United States) statistical software. Parameters, that is, age, gender, location of aneurysm, Hunt and Hess score, Fisher's score, World Federation of Neurosurgery score (WFNS), acute PHH requiring CSF diversion, intracerebral hemorrhage, and intraventricular hemorrhage were put into the binary logistic regression analysis to determine the relationship of the parameters with shunt dependency as shown in ►Table 4. The specificity and sensitivity of CHESS score in our cohort were calculated. Multilogic regression analysis was ran to determine the chances of shunting with CHESS score.

Results

During the period of study, a total of 131 patients were treated for postaneurysmal SAH in the two aforementioned institutions. Of this group of patients, there were 41 patients (31.3%) who developed chronic posthemorrhagic hydrocephalus and required permanent CSF diversion. We observed 84 patients with a CHESS score of ≤6 who were not shunted, where seven patients with CHESS score of ≥6 were not shunted. In the group of patients with CHESS score ≥6, 30 patients underwent shunting, while 11 patients with CHESS score of <6 were shunted. ►Table 2 shows the above stated findings and we concluded that 73.2% of patients with CHESS score of ≥6 were shunted while 93.3% of patients with CHESS score of <6 were not shunted (shown in ►Table 3).

Binary logistic regression analysis studies the relationship between each of the variables with shunt dependency, and variable which had the strongest relationship with shunt dependency was identified. CHESS score was found to have a p-value of < 0.001 and odds ratio (OR) of 2.184. It was also found that only two other variables had a statistically significant relationship with shunt dependency, namely, early infarction on CT and Fisher's score of >3 both with a p-value of <0.05 and OR of 0.182 and 1.986, respectively (shown in ►Tables 4 and 5).

The sensitivity and specificity for CHESS score in this cohort population showed a sensitivity of 73.2% and specificity of 93.3%. The area under the curve for CHESS score in our cohort is 0.922 (►Table 6) indicating a better diagnostic accuracy comparing to the area under the curve of 0.885 from the original CHESS score study.[1]

The multilogic regression analysis for the CHESS score showed that an increment of a single point in CHESS score will lead to an increased chance of shunting by twice.

Table 1   Analyzed parameters

Age	>50 years old <50 years old
Gender	Male Female

Hunt and Hess score as seen on first CT scan done after aneurysm rupture	Good grades:
	   Grade 1: asymptomatic, mild headache, or nuchal rigidity
	   Grade 2: moderate to Severe headache, no neurological deficit except for cranial nerves palsy
	   Grade 3: drowsiness, confusion, or mild focal neurological deficit
	Poor grades:
	   Grade 4: stupor, moderate to severe hemiparesis, early decerebrate posture
	   Grade 5: comatose, decerebrate posture

Location of aneurysm rupture	Anterior circulation Posterior circulation
Acute Posthemorrhagic hydrocephalus requiring drainage	Yes No
Intraventricular hemorrhage as seen on the first CT scan done after aneurysm rupture	Yes No
Early Infarction on CT scan (up to 72 hours after the aneurysm rupture)	Yes No

World Federation of Neurosurgery score (WFNS score) on admission	Good grade:
	   Grade 1: GCS score of 15 without focal deficit
	   Grade 2: GCS score of 13 or 14 without focal deficit
	   Grade 3: GCS score of 13 or 14 with focal deficit
	Poor grade:
	   Grade 4: GCS score of 7–12, any deficit
	   Grade 5: GCS score of 3–6, any deficit

Fisher score as seen on first CT scan done after aneurysm rupture	Good grade:
	   Score 1: no blood on CT scan
	   Score 2: diffuse or thin layer of blood less than 1 mm thickness in the vertical plane (at interhemispheric, insular, or ambient cisterns)
	Poor grade:
	   Score 3: localized clots and/or layers of blood greater than 1 mm thickness in the vertical plane (at interhemispheric, insular, or ambient cisterns)
	   Grade 4: intracerebral blood clot

Intracerebral hemorrhage as seen on the first CT scan done after aneurysm rupture	Yes No
Treatment modality	Surgical Endovascular

Abbreviations: CT, computed tomography; GCS, Glasgow Coma Scale.

Moreover the likelihood of shunting is increased by 38 times in patients with CHESS score of more than 6 as shown in ►**Table 7**.

Discussion

Aneurysmal bleed and its complications have always been a challenge for neurosurgeons to manage and PHH is one of them. The difficulty faced by most neurosurgeons is in the decision-making process to identify the group of patients who will be shunt dependent. To date, many studies have published factors influencing posthemorrhagic hydrocephalus[7-16] but no comprehensive and accurate diagnostic tool is available that is widely accepted in predicting the need for shunt in such patients. Many centers will typically manage these patients by gradually "challenging" the external ventricular drain (EVD) by increasing the height of the EVD to decide if the patients require shunt. Shunt placement in such patients can often be delayed due to multiple factors, such as ventricle related factors, that is, ventriculitis, unfavorable CSF condition high-protein count of >1.5, or heavily blood-stained CSF. Other systemic factors, such as sepsis, secondary hospital-acquired pneumonia, skin infections, also come into play. All these factors will eventually lead to prolonged hospitalization[17,18] which is often due to repeated surgical interventions and complications associated with hydrocephalus and ventriculoperitoneal shunt.[18] This also leads to the increase in medical treatment cost[19] which has an unfavorable financial implication for government-funded tertiary centers, that is, health care providers in Malaysia and also patients' medical insurance. Failure to identify and treat the shunt-dependent PHH, patients promptly associated with higher neurological morbidity.[17,20] Therefore, there is a need for a tool to identify this group of

Table 2 Observed no. of patients and its CHESS score

CHESS Score	No. of observed patients
0–5 with shunt	11
0–5 without shunt	84
6–8 with shunt	30
6–8 without shunt	6
Total	131

Abbreviation: CHESS, chronic hydrocephalus ensuing subarachnoid hemorrhage score.

patients who are shunt dependent to reduce the morbidity caused by posthemorrhagic hydrocephalus.

CHESS score accuracy in early prediction of shunt dependency in post-SAH patients by was well demonstrated

Table 3 Percentage of patients with and without shunt in relation to CHESS score

CHESS score	No. of patients	%
Patients with shunt		
≥ 6	30	73.2
< 6	11	26.8
Total	41	100
Patients without shunt		
CHESS score		
≥ 6	7	6.7
< 6	84	93.3
Total	91	100

Table 4 Binary logistic regression analysis for all parameters

			Score	df	Sig.
Step 1	Variables	Age	3.559	1	0.059
		Aneurysm Location (Posterior)	1.451	1	0.228
		WFNS	0.173	1	0.677
		Fisher	4.151	1	0.042
		Hunt and Hess	0.046	1	0.831
		Treatment - Clipping	2.396	1	0.122
		EICT (1)	9.037	1	0.003
		ICH (1)	0.015	1	0.902
		IVH (1)	2.509	1	0.113
		PHH (1)	0.035	1	0.851
		Gender - Female	1.226	1	0.268
	Overall statistics		19.346	11	0.055
Step 2	Variables	Age	1.672	1	0.196
		Aneurysm Location (Posterior)	0.988	1	0.320
		WFNS	0.989	1	0.320
		Fisher	4.221	1	0.040
		Hunt and Hess	0.148	1	0.701
		Treatment - Clipping	0.449	1	0.503
		ICH (1)	0.169	1	0.681
		IVH (1)	2.326	1	0.127
		PHH (1)	0.009	1	0.923
		Gender - Female	0.843	1	0.359
	Overall statistics		12.452	10	0.256
Step 3	Variables	Age	1.648	1	0.199
		Aneurysm Location (Posterior)	0.564	1	0.453
		WFNS	1.019	1	0.313
		Hunt and Hess	0.073	1	0.786
		Treatment - Clipping	0.722	1	0.395
		ICH (1)	0.561	1	0.454
		IVH (1)	0.174	1	0.676
		PHH (1)	0.133	1	0.716
		Gender - Female	2.211	1	0.137
	Overall statistics		9.003	9	0.437

Abbreviations: EICT, early infarct on computed tomography; ICH, intracerebral hemorrhage; IVH, intraventricular hemorrhage; PHH, posthemorrhagic hydrocephalus; WFNS, World Federation of Neurosurgery score.

Table 5 Final binary logistic regression analysis

		p-Value	Odds ratio	95% CI for Odds ratio	
				Lower	Upper
Step 1[a]	CHESS	0.000	2.332	1.761	3.090
	Constant	0.000	0.015		
Step 2[b]	EICT (1)	0.004	0.190	0.061	0.592
	CHESS	0.000	2.244	1.678	3.000
	Constant	0.000	0.040		
Step 3[c]	Fisher	0.047	1.986	1.008	3.913
	EICT (1)	0.004	0.182	0.056	0.588
	CHESS	0.000	2.184	1.608	2.967
	Constant	0.000	0.005		

Abbreviations: CHESS, chronic hydrocephalus ensuing subarachnoid hemorrhage score; CI, confidence interval.
[a]Variable(s) entered on step 1: CHESS.
[b]Variable(s) entered on step 2: EICT.
[c]Variable(s) entered on step 3: Fisher.

Table 6 Area under the curve

Area under the curve				
Test result variable(s): CHESS				
Area	SE[a]	Asymptotic Sig.[b]	Asymptotic 95% CI	
			Upper bound	Lower bound
0.922	0.023	0.000	0.877	0.966

Abbreviations: CHESS, chronic hydrocephalus ensuing subarachnoid hemorrhage score; CI, confidence interval; SE, standard error.
Note: the test result variable(s): chess has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
[a]Under the nonparametric assumption.
[b]Null hypothesis: true area = 0.5.

Table 7 Multilogic regression analysis of CHESS score

Variables in the equation						
	B	SE	Wald	df	*p*-Value	Odds ratio
1) CHESS	0.847	0.144	34.831	1	0.000	2.332
2) CHESS 6–8 vs. 0–5	3.642	0.550	43.812	1	0.000	38.182

Abbreviations: CHESS, chronic hydrocephalus ensuing subarachnoid hemorrhage score; SE, standard error.

(*P*-value = 0.0007) and CHESS score of ≥6 showed significant higher risk in developing shunt-dependent hydrocephalus (*p* < 0.001).[1] CHESS score predictive value was further shown by another institution[21] while doing a study to create a new scoring system to predict shunt dependency PHH. CHESS score from our study showed a strong predictive value with an OR of 2.184 and *p* < 0.001.

In our study, we noted that early cerebral infarction on CT and Fisher's score has a strong relationship with development of shunt-dependent hydrocephalus post-SAH. Other parameters, however, did not show any statistically significant correlation with shunt dependency.

With the result from this study, we found that CHESS score predictive value is consistent with the published result.[1] Our findings will help us in detecting shunt-dependent PHH early, thus reducing the complications caused by hydrocephalus. Also because of the limited number of secondary and tertiary centers in Malaysia, application of CHESS score in our practice will reduce congestion in wards by expediting the decision-making process for shunt dependency in post-SAH patients. The CHESS score will also provide a clear and uniform management pathway for hydrocephalus in post-SAH patients in centers in Malaysia, owing to the easily replicable and reproducible scoring system, regardless of the status of neurosurgery center, that is, secondary or tertiary.

As stated earlier, this study was conducted in a retrospective manner, a follow-up prospective study may be useful in further validating CHESS score accuracy and Fisher's score could also be incorporated in creating a new and better score to improve the reliability in prediction of shunt-dependent PHH.

Study Limitations

This is a retrospective study. Other contributory factors include the number of patients who were lost to follow-up. In this study, the median period of PHH development leading to shunt was set at 60 days in this study, based on the median period of 54 days from the original research.[1] Thus, there is a possibility that chronic hydrocephalus may develop up to 1-year post-SAH.[19] Therefore, in future a prospective cohort study with a longer period of data collection and observation of up to 1 year can be done in the future to further strengthen the accuracy of CHESS score.

Conclusion

The CHESS score is a reliable tool in predicting shunt dependency post-SAH. It is simple and easy to apply and the result is available within 72 hours. Although this is a retrospective study, this score was applied and validated externally by our institution. The results are promising and a prospective study for application of CHESS score needs to be conducted to further evaluate its reliability.

Conflict of Interest
None declared.

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