Paediatrica Indonesiana

VOLUME 55 May • 2015 NUMBER 3

Original Article

The accuracy of a clinical parameters-based scoring system to predict spontaneous intracranial hemorrhage in children under one year old

Harris Alfan[1], Rita Dewi Arifin[1], Erial Bahar[2], Syarif Darwin Ansori[1]

Abstract

Background Previous studies show that most children aged less than 1 year had intracranial hemorrhage without any history of trauma. The sign and symptoms of spontaneous intracranial hemorrhage (SIH) in children varies. To minimize morbidity and mortality, early detection and accurate diagnosis are required. Head CT scans area widely used for diagnosing SIH. Unfortunately, not all health facilities in Indonesia have CT scans.

Objective To determine the accuracy of a clinical parameters-based scoring system in predicting spontaneous intracranial hemorrhage (SIH) in children under one year old.

Methods This diagnostic study included children aged under one year who were admitted to Mohammad Hoesin Hospital, Palembang. Patients who showed any signs of increased intracranial pressure were recruited. Data were collected from medical records from January 2007 to September 2013. Through the use of logistic regression analysis, clinical parameters showing significant relationships with computerized tomography (CT)-scan confirmed SIH were selected as predictors. Each predictor was given a score based on an adjusted ratio. The cut-off point of the total scores from all patients was determined using a receiver operating curve (ROC) analysis. The accuracy of the total scores was calculated using a 2x2 validity test.

Results Of the 186 children included in this study, 98 (52.7%) had SIH and 93 (94.8%) were under 3 month-old. The predictors for SIH used included age (>3 months: score 0; 1-3 months: score 3), gender (female: score 0; male: score 1), pallor (no: score 0; yes: score 1), bulging fontanel (no: score 0; yes: score 1), pupil (isocoria: score 0; anisocoria: score 2) and history of shaken baby (no: score 0; yes: score 3). The ROC analysis showed that the area under the curve (AUC) was 95.3% with a cut-off point of 4.5, had a sensitivity of 88.7% and a specificity of 93.1%

Conclusion This scoring system based on clinical parameters had good accuracy for predicting SIH in children under 1 year of age who exhibited signs of increased intracranial pressure. **[Paediatr Indones. 2015;55:147-52.]**

Keywords: *spontaneous intracranial hemorrhage, scoring system, clinical parameters*

Intracranial hemorrhage is extravasation of blood to the brain or intracranial tissue due to damaged or abnormal blood vessels.[1] It can be caused by head trauma or occur spontaneously. Spontaneous intracranial hemorrhage (SIH) is caused by damage to the blood vessels in the brain, such as arterial aneurysm and arteriovenous malformation. Additionally, SIH may also be caused by coagulation disorders such as hemophilia or vitamin K deficiency.[2]

A study conducted by Kardana *et al*. found that from 56 children with intracranial hemorrhages, 43 children (77%) were aged less than 1 year and 40 children (71%) had SIH without any history of

From the Departments of Child Health[1] and Biostatistics[2], Sriwijaya University Medical School/Moh Hoesin Hospital, Palembang, Indonesia.

Reprint requests to: Harris Alfan, Department of Child Health, Sriwijaya University Faculty of Medicine, Moh Hoesin Hospital, Jl. Jend. Sudirman Km. 3.5, Palembang, Indonesia. Tel +62-816-1929271, Fax +62-711-376445, Email: harris_alfan @yahoo.co.id.

trauma.[3] An initial study conducted from January 2007 to December 2011 at Mohammad Hoesin Hospital in Palembang found 55 cases of intracranial hemorrhage, of whom 52 (94%) children were less than 1 year old, with an average age of 2.6 months. Fifty of these children (90%) had no apparent history of head trauma. The location of intracranial hemorrhage was most commonly subdural, found in 33 (60%) children.[4]

The signs and symptoms of intracranial hemorrhage in children vary from no symptoms to critical or even fatal ones. To minimize morbidity and mortality, early detection and accurate diagnosis are required, particularly for children showing no clear clinical symptoms.[5] Distinguishing SIH in children under one year of age from other neurological diseases is sometimes difficult in practice.[6] Head CT scans are widely used for diagnosing SIH.[7] Unfortunately, not all health facilities in Indonesia have CT scans. In areas where a CT scan is unavailable, clinical parameters may be used to predict SIH before a CT scan can be done.[8] We report here the first investigation of the validity of a scoring system based on clinical parameters to predict SIH in children under one year old.

Methods

A diagnostic test was conducted on children suspected to have intracranial hemorrhages in the Pediatric Ward of Mohammad Hoesin Hospital, Palembang. Medical records from January 2007 to September 2013 were reviewed and the search focused on children less than one year of age with at least one sign of increased intracranial pressure as well as CT scan results. We excluded patients with history of head trauma, aged less than one month or incomplete medical records.

We collected data on patients' age, gender, and clinical parameters such as level of consciousness, history of shaken baby, history of vitamin K injection, seizure, vomiting, pallor, bulging fontanelle, pupil size, and complete blood count. The presence of intracranial hemorrhage was confirmed by means of CT scan examination.

Spontaneous intracranial hemorrhage was defined as extravasation of blood to the brain or intracranial tissue due to damaged or abnormal blood vessels without any history of head trauma. Suspected intracranial hemorrhage was defined as children with at least one sign of increased intracranial pressure: loss of consciousness, bulging fontanelle, vomiting, anisocoria pupil, decreased light reflex, and bradycardia. Patients were divided into two age groups: 1 to 3 months and 3 to 12 months of age. Pallor is a clinical sign of anemia and was assessed by physical examination of the palms and conjunctivae and confirmed with hemoglobin levels below 8 mg/dL.

Logistic regression analysis was done to select clinical parameters that could be used to predict SIH, as well as to determine the adjusted OR of those parameters. Each clinical parameter was given a score based on the adjusted ratio as follows: score 3 for $OR_{adj.} > 20$, score 2 for $OR_{adj.}$ 11-20, or score 1 for $OR_{adj.} < 11$. Analysis of a receiver operating curve (ROC) was done to obtain the optimal cut-off point of the total clinical parameters score. Validity tests (sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, and negative likelihood ratio) were performed to obtain diagnostic values of the clinical parameter score to predict SIH. Statistical analyses were performed using *SPSS statistic version 15.0*. This study was approved by the Ethics Committee of Sriwijaya University Medical School and Mohammad Hoesin Hospital, Palembang, Indonesia.

Results

A total of 186 children suspected of having SIH were identified from medical records. Ninety-eight (52.7%) children had intracranial hemorrhages confirmed by head CT-scan examinations, whereas 88 (47.3%) children had non-hemorrhagic findings. The types of intracranial hemorrhages observed were subdural hemorrhage in 58 (59%) patients, intracerebral hemorrhage in 25 (26%) patients, subarachnoid hemorrhage in 8 (8%) patients, intraventricular hemorrhage in 6 (6%) patients and epidural hemorrhage in 1 (1.5%) patient.

A comparison of the two groups with regards to clinical parameters is shown in **Table 1**. In the intracranial hemorrhage group, more than half of the subjects were male and almost all were less than three month old. The most common findings in this group were a history of shaken baby (97.7%), pupil anisocoria

(86.9%), pallor (86.7%), bulging fontanelle (73.6%), no history of vitamin K injection (73.3%), vomiting (61.5%), decreased level of consciousness (61.1%), and seizures (56%).

Logistic regression analysis was done to determine the adjusted odds ratios and to assess for significant associations between clinical parameters intracranial hemorrhage which could then be used as predictors for SIH (**Table 2**). Logistic regression analysis revealed only 6 clinical parameters that could be used to predict SIH: age (OR 78.01), followed by history of shaken baby (OR 42.13), pupil anisocoria (OR 13.02), pallor (OR 5.84), gender (OR 3.33), and bulging fontanelle (OR 2.93).

After trying several scoring systems with empirical methods to look for a good scoring system, then the method were obtained using adjusted odds ratios from the multivariate analysis. Scores for clinical parameters were given based on adjusted odds ratio as follows:

Table 1. Characteristics of subjects (n=186)

Characteristics	Spontaneous intracranial hemorrhage			
	Yes (N=98)		No (N=88)	
	n	%	n	%
Gender				
Male	66	67.3	39	44.3
Female	32	32.7	49	55.7
Age				
1-3 months	93	94.9	21	23.9
>3-12 months	5	5.1	67	76.1
Glasgow Coma Scale				
<13	82	83.7	52	59.1
13-15	16	16.3	36	40.9
Seizure				
Yes	88	89.8	69	78.4
No	10	10.2	19	21.6
Pallor				
Yes	59	60.2	9	10.2
No	39	39.8	79	89.8
History of vitamin K injection				
Yes	65	66.3	76	86.4
No	33	33.7	12	13.6
History of shaken baby				
Yes	43	43.9	1	1.1
No	55	56.1	87	98.8
Bulging fontanel				
Yes	81	82.7	29	33.0
No	17	17.3	59	67.0
Pupils diameter				
Anisocoria	40	40.8	6	6.8
Isocoria	58	59.2	82	93.2

Table 2. Clinical parameters selected as predictors of SIH by logistic regression analysis

Variables	Coefficient	P	OR adj.	CI
Age	4.357	0.001	78.014	13.526 to 449.942
Gender	1.203	0.049	3.330	1.007 to 11.006
History of shaken baby	3.741	0.004	42.133	3.415 to 519.868
Bulging fontanelle	1.078	0.063	2.937	0.942 to 9.157
Pupil anisocoria	2.567	0.010	13.027	1.853 to 91.587
Pallor	1.766	0.009	5.847	1.567 to 21.816
Coefficient	-5.641			

P=0.05; OR adj. = adjusted odds ratio; CI = confidence interval

OR_{adj} >20 was given score 3; OR_{adj} 11-20 was given score 2; and OR_{adj} <11 was given score 1 (**Table 3**).

To find out the optimal cut-off point of the clinical parameter score, a ROC analysis was done. According to the ROC, the AUC value was 97.1% (95%CI 91.7 to 99%; P<0.001) (**Figure 1**).

The optimal cut-off point of the clinical parameters score from ROC analysis to predict SIH was 4.5 (**Figure 2**).

At this optimal cut-off point of score clinical parameters, the sensitivity was 88.7%, specificity 93.1%, PPV 93.5% and NPV 88.1% (**Table 4**).

Table 3. Scoring system for clinical parameters based on adjusted odds ratio to predict SIH

Clinical parameters \ Score	0	1	2	3
Age	>3 months			1-3 months
Gender	Female	Male		
Pallor	No	Yes		
History of shaken baby	No			Yes
Bulging fontanelle	No	Yes		
Pupils diameter	Isocoria		Anisocoria	

Table 4. Validity test for clinical parameter score to predict SIH with a cut-off point > 4.5 (n=186)

Score	Spontaneous intracranial hemorrhage		Total
	Yes	No	
>4.5	87	6	95
≤4.5	11	82	93
Total	98	88	186

(Sensitivity 88.7%; specificity 93.1%; positive predictive value 93.5%; negative predictive value 88.1%; positive likelihood ratio 13.02; negative likelihood ratio 0.12)

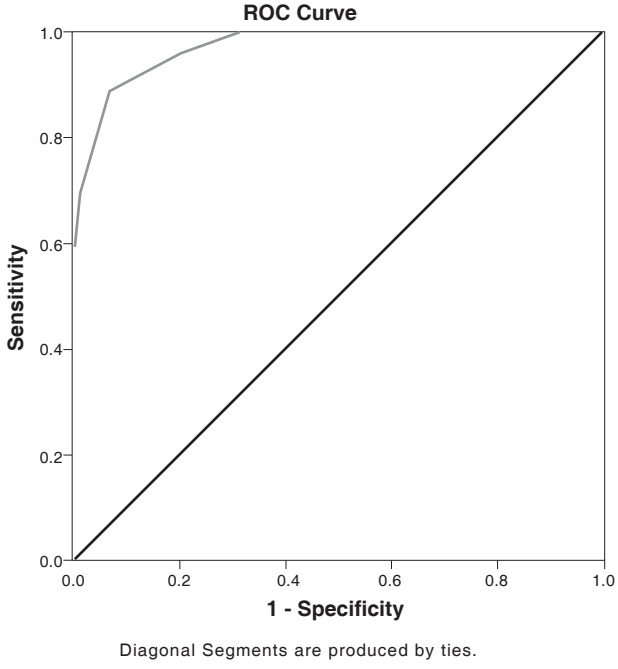

Figure 1. Receiver operator curve (ROC) for clinical parameters score

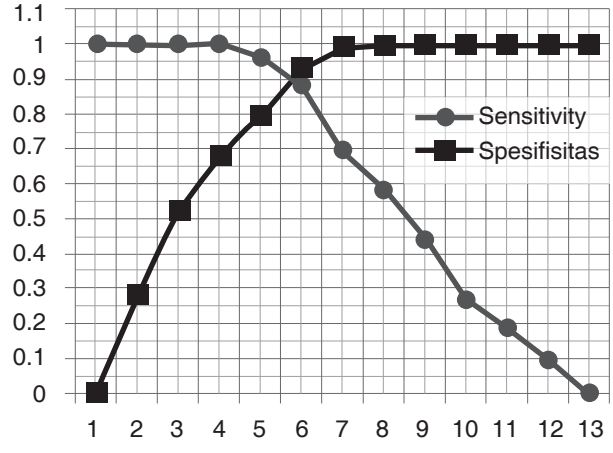

Figure 2. Sensitivity and specificity curve of score clinical parameters

Discussion

Spontaneous intracranial hemorrhage is one of the health problems that causes mortality in children. The initial signs and symptoms of SIH in children less than one year old are often subtle.[5,9] Since not all health facilities in Indonesia have CT-scanners to confirm the diagnosis, the problem may be fatal. Considering the magnitude of this problem, we attempted to develop a simple and affordable tool to predict intracranial hemorrhage prior to CT scan examination. This is the first study reporting on the validity of a clinical parameters-based scoring system to predict SIH in children under one year old.

In this study, we proposed that age, gender, history of shaken baby, bulging fontanelle, pupil anisocoria and pallor are clinical parameters that can help predict SIH in children under one year old with at least one of sign of increased intracranial pressure. This scoring system was made from adjusted odds ratios as follows: OR_{adj} >20 was given score 3; OR_{adj} 11-20 was given score 2; and OR_{adj} <11 was given score 1. By applying this scoring system, every patient in this study had a total clinical score. A cut-off point of 4.5 was determined by ROC curve analysis, leading to an AUC of 97.1%. Further analysis using a 2x2 validity test also yielded convincing results with sensitivity 88.7%, specificity 93.1% positive predictive value 93.5%, and negative predictive value 88.1%.

This scoring system is not intended to replace head CT scans to diagnose SIH. With this scoring system, we expect that health workers in remote areas without CT scanners may be able to make earlier predictions of SIH. As such, patients with suspected SIH can be referred sooner to a more complete health facility.

In this study, patients were divided into two age groups: 1-3 months and >3-12 months. This grouping was based on the results of our previous study which showed that the average age of SIH was 2.6 months.[4] Hence, we had 93 (94.8%) patients with SIH in the 1-3 month old group, and more males than females (62.8% vs 37.2%, respectively). Similarly, Greenes *et al*. found that intracranial hemorrhage was more frequent in male children below three months of age.[9] Other studies in Indonesia by Kardana *et al*.[2] and July *et al*.[10] also found similar results. A plausible, simple explanation of this high incidence of SIH in the 1-3 month-old children may be due to their softer, readily movable skull. Hence, the intracranial blood vessels can be easily damaged from shaking the head, as seen in shaken baby syndrome. In addition, abnormalities in coagulopathy factors such as vitamin K deficiency frequently occurs in children of this age group.[11]

Subdural hemorrhage was the most common type of hemorrhage found in this study, followed by intracerebral hemorrhage. This finding differs from a study by Meyer-Heim *et al*. who found intracerebral hemorrhage to be the most common type of SIH.[9] On the other hand, Kardana *et al*.[2] and July *et al*.[10] had similar findings to ours. The elasticity of the infant skull, which in the presence of acceleration/deceleration movements can lead to bleeding. Skull elasticity may contribute to the high incidence of subdural hemorrhage in children less than one year old.[12,13] In addition, Geddes *et al*. showed that the presence of severe hypoxia, cerebral edema, and increased central venous pressure can lead to bleeding from the intracranial vein into the subdural space.[14]

The most common findings in the intracranial hemorrhage group were history of shaken baby (97.7%) and anisocoria (86.9%), followed by pallor (86.7%), bulging fontanelle (73,6%), no history of vitamin K injection (73.3%), vomiting (61.5%), decreased level of consciousness (61.1%) and seizures (56%). Meyer-Heim *et al*. found that 26.5% of children younger than 3 years with SIH had non-specific signs and symptoms, such as deterioration of general condition, increased crying and sleepiness, irritability, feeding difficulty, vomiting, and sepsis-like symptoms with cold extremities.[9] In intracranial hemorrhage, the presence of hematoma, tissue ischemia and cerebral edema can increase the intracranial pressure, leading to neurological deficits. Furthermore, bleeding can cause anemia which can be seen as the presence of pallor on the palms or the conjunctivae.[15-17]

In conclusion, the scoring system based on clinical parameters (age, history of shaken baby, anisocoria of the pupils, pallor, gender, and bulging fontanelle) with a cut-off point > 4.5 is a valid and accurate method to predict spontaneous intracranial hemorrhage in children less than one year of age who show signs of increased intracranial pressure. Furthermore, in order to improve this scoring system, we recommend applying it to new cases to test its reliability.

Acknowledgments

We thank Prof. Dr. Rusdi Ismail, SpA(K) and Dr. Achirul Bakrie, SpA(K) for reviewing the manuscript. We also thank Dr. Yusmala Helmi SpA(K) and Dr. Herman Bermawi, SpA(K) for their critical comments on this study report.

Conflict of interest

None declared.

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