ORIGINAL ARTICLE

GCRBS Score: A New Scoring System for Predicting Outcome in Severe Falciparum Malaria

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Abstract

Objectives : Severe falciparum malaria is a critical illness resulting in multi-organ dysfunction and death. Severe malaria is defined by the World Health Organisation as a qualitative variable. The purpose of this study is to devise a scoring system for predicting outcome in severe falciparum malaria.

Methods : 112 cases of severe falciparum malaria diagnosed as per the WHO criteria, were evaluated to determine the parameters which were significantly associated with mortality. Of all the parameters studied, five variables namely cerebral malaria (GCS < 11), Renal failure (Creatinine > 3 mg/dl), Respiratory distress (Respiratory rate > 24/min), Jaundice (Bilirubin >10 mg/dl) and Shock (Systolic BP < 90 mm of Hg) were all found to be associated with a poor prognosis.

Results : . The five selected parameters were analysed using the Odds ratio and a new scoring system named as GCRBS score was designed with a possible score from 0-10. With a cut-off score of 5, the GCRBS score predicted mortality with a sensitivity of 85.3% and a specificity of 95.6%.

Conclusion : The GCRBS score is easy to calculate and apply. Of the 5 parameters, 3 are clinical which can be determined at bedside and only 2 are biochemical which can be done in any laboratory. The most important advantage of this scoring system is that all the 5 parameters are to be assessed quantitatively for allotting a score, which would eliminate the possibility of observer bias.

Introduction

Malaria is an important cause of death and illness in children and adults, especially in tropical countries. As per World malaria report 2010 malaria accounted for a total of 225 million cases globally causing 781000 deaths in 2009. Of these 34 million cases were in South East Asian Region causing 49000 deaths.[1] India reports approximately two-thirds of all confirmed malaria cases in the South-East Asia Region, with five states accounting for 60% of these cases: Orissa, Chhattisgarh, Madhya Pradesh, Jharkhand and West Bengal.[1] However in a recently published article the malaria deaths per year in India has been estimated to be around 205,000 with only Orissa accounting for more than 50000 deaths.[2]

WHO enumerates a list of complications for severe falciparum malaria but the importance of each complication has not been assigned.[3,4] For the patients with critical illness various scoring systems have been devised to determine the prognosis. Since severe falciparum malaria is associated with high mortality, a SCORING system for predicting the outcome will be of great help for the treating clinician in identifying patients needing more intensive medical care and to prognosticate the chances of survival.

Mishra et al devised a Malaria Score for Adults[5] (MSA) to prognosticate the outcome in severe falciparum malaria. This score is based on four parameters namely severe anaemia, acute renal failure, respiratory distress and cerebral malaria. With a cut-off

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Received: 30.10.2012; Revised: 01.01.2013; Accepted: 07.02.2013

Table 1 : Calculation of ODDS RATIO and allotment of score to each parameter as per severity

Parameter	Value	Death	Survival	ODDS ratio	P value	Score alloted
	< x	A	b	a x d		
	≥ x	C	d	b x c		
GCS	< 7	11	8	9.281	<0.0001	3
	≥ 7	12	81			
	< 11	19	50	3.705	0.0291	1
	≥ 11	4	39			
Creatinine (in mg/dl)	≥ 3	20	40	5.778	0.0003	2
	< 3	3	49			
Respiratory Rate (per min)	> 24	12	13	6.378	0.0004	2
	≤ 24	11	76			
Bilirubin (in mg/dl)	≥ 10	16	23	6.559	0.0002	2
	< 10	7	66			
Systolic BP (in mm of Hg)	< 90	7	10	3.456	0.0443	1
	≥ 90	16	79			

Table 2 : The GCRBS score

Parameter		Score
GCS	3-6	3
	7-10	1
	11-15	0
Creatinine (in mg/dl)	> 3	2
	≤ 3	0
Respiratory rate	> 24	2
	≤ 24	0
Bilirubin (in mg/dl)	> 10	2
	≤ 10	0
Systolic BP	< 90	1
	≥ 90	0

score of 5, the sensitivity and positive predictive value for mortality was 89.9% and 94.1% respectively

Wilairatana et al in Bangkok, Thailand applied the APACHE II[6] scoring to stratify the prognosis in patient of cerebral malaria. With the cutoff point at a score of 24, the APACHE II score stratified the patient's mortality outcome with 95.8% accuracy.[7]

Teano R et al. proposed a Clinical Scoring Index[8] for predicting outcome in cerebral malaria with a possible score of 0-14. Level of consciousness, multiple convulsions, laboured respiration, circulatory collapse and abnormal bleeding were the parameters taken for calculating the score. With an optimum score of 7, it could predict mortality with a sensitivity of 92% and specificity of 95%.

MK Mohapatra, SP Das devised a Malaria Severity Score[9] for Severity Assessment and Risk Prediction of Hospital Mortality for Falciparum Malaria in Adults. There is a score for each organ dysfunction according to its severity level and for each score there is also a probability of mortality.

Material and Methods

This study was conducted in the department of medicine S.C.B. Medical College, Cuttack, Orissa, a tertiary care hospital catering to the whole state of Orissa and neighbouring districts of west Bengal and Jharkhand.

A total of 112 patients diagnosed to be severe falciparum malaria as per WHO criteria 2006[4] admitted to medicine ward of SCB Medical College, Cuttack were taken into the study. Malaria diagnosis was confirmed by Thick or thin smear/ Optimal test/ Immunochromatographic test positive for falciparum malaria.

A detailed clinical evaluation of each patient including history and physical examination was done. Investigations including haemoglobin, DC, TLC, Serum urea, serum creatinine, Liver function test and Arterial blood gas analysis was done for all patients.

All the cases were treated with Artesunate (2.4 mg/kg stat IV followed by 2.4 mg/kg at 12 and 24 h and then daily followed by a full course of an effective ACT (artemisinin-based combinations therapy) and then Primaquine for radical cure. Supportive therapy was given as per standard recommendations on case to case basis. Blood transfusion (whole blood/ packed cell/ fresh blood) was given in patients with Haematocrit < 20% or with bleeding manifestations/ DIC. Mechanical ventilation was provided to patients with pulmonary oedema/ARDS. Inotrope support (Dopamine/ Nor-adrenaline) was given in patients with shock not improving with IV fluids. Patients with renal failure requiring dialysis were given haemodialysis sessions as per need.

Clinical findings, haematological and biochemical investigations were analysed using SPSS v16 and Instat 3 software.Variables which had significant correlation to clinical outcome were subjected to Chi-square analysis (or Fischer exact probability test where applicable) with a variable considered significant if $p \leq 0.05$. The clinical parameters associated with an unfavourable outcome were analysed using the Odds ratio. In this study, the Odds ratios express how many

Table 3 : Computation of sensitivity and specificity for GCRBS score

Score	Survival	Death	Sensitivity	Specificity
<x	a	b	(a/a+c)x100	(d/b+d) x100
≥x	c	d		
<3	41	0	46.1%	100%
≥3	48	23		
<4	67	0	75.2%	100%
≥4	22	23		
<5	76	1	85.3%	95.6%
≥5	13	22		
<6	85	7	95.5%	69.6%
≥6	4	16		
<7	85	13	95.5%	43.5%
≥7	4	10		
<8	88	19	98.8%	17.4%
≥8	1	4		

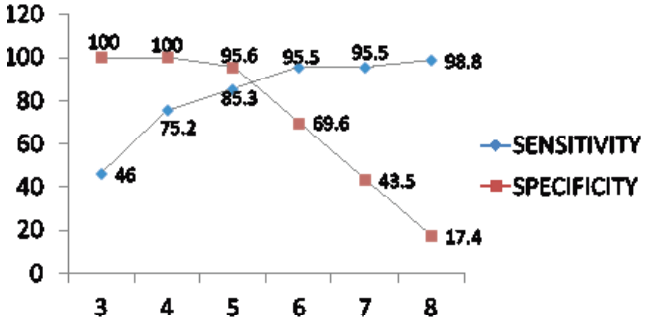

Fig. 1 : ROC Curve for calculating cut-off score for GCRBS score

times a clinical parameter is likely to be found in the death group as compared to the survival group. The computed odds ratios were divided by three to avoid a wide range of score. This is possible because there was no computed odds ratio equivalent to zero. The highest possible score is 10, while the lowest is 0. The higher the score, the poorer the prognosis.

The proposed scoring index was tested on the original 112 patients diagnosed with severe falciparum malaria. The score for each patient was obtained by adding the specific values designated for the presence of the clinical parameters. Sensitivity and specificity for each clinical score were computed and the values obtained were plotted on an ROC[10] (Receiver Operating Characteristic) curve to determine the best cut-off point. Malaria Score for Adults,[5] APACHE II Score[7] and Clinical Scoring Index[8] was also calculated for all cases and compared using standard statistical methods.

Results

The study to develop the score included 112 severe malaria patients with 23 deaths. The cases had a mean age of 35.8 ± 15.1 years. Only 18 cases were female

Table 4 : Comparison with other scoring systems

Scoring system	Cut-off score	Sensitivity (%)	Specificity (%)
Apache II	24	98.8	17.4
MSA	5	63	95.6
CSI	7	91	70
GCRBS	5	85.3	95.6

of which 2 died. There was no significant difference in the age and sex of the survival and death group.

All the variables were analysed (viz., age, gender, Glasgow Coma score (GCS), hyperpyrexia, hypotension, severe anaemia, acute renal failure, jaundice, hypoglycaemia, respiratory rate). Of these cerebral malaria (**G**CS < 11), Renal failure (**C**reatinine > 3 mg /dl), Respiratory distress (**R**espiratory rate > 24/min), Jaundice (**B**ilirubin > 10 mg/dl) and Shock (**S**ystolic BP < 90 mm of Hg) were significantly associated with death ($p < 0.05$) (Table 1).

The computed odds ratios for the 5 clinical parameters that were shown to be significantly associated with poor outcome are shown in Table 1. Table 2 shows the proposed GCRBS score for predicting outcome in severe falciparum malaria. A score of 5 was selected as the best cut-off point with sensitivity of 85.3%, specificity of 95.6% (Table 3). As seen in the ROC curve (Figure 1), this cut-off point is the best compromise between maximum sensitivity and maximum specificity and therefore the best cut-off in terms of predicting unfavourable outcome in severe falciparum malaria. Table 4 shows the comparison between sensitivity and specificity of GCRBS score with other scores at their respective cut-off scores.

Discussion

The clinical course of severe malaria is variable depending on the presence of one or several complications. There are numerous severity-of-illness scoring systems that have been developed and validated as tools to accurately assess populations of critically ill patients. Currently, the most commonly utilised scoring systems are the APACHE (acute physiology and chronic health evaluation) system, the MPM (mortality probability model), and the SAPS (simplified acute physiology score) system, all designed to predict outcomes in critical illness.

In this study APACHE II[6], Clinical Scoring Index(CSI)[8] and Malaria Score for Adults[5] (MSA) were calculated for each patient and sensitivity and specificity were calculated at the cut-off scores determined in the original studies. In contrast to the study by *Wilairatana et al* in our study only 4 patients in the death group had an APACHE II score of 24 or more resulting in a very low specificity of

17.4%. Similarly at a CSI score of 7 the sensitivity and specificity was 91% and 70% respectively in our study as compared to a sensitivity of 92% and specificity of 95% in the study by *Teano R et al.*

The results for MSA score were also quite different. Compared to a sensitivity of 89.9% in the study by *Mishra et al* at a cut off score of 5, the sensitivity turned out to be just 63% in the current study.

The APACHE II score is difficult to remember, cumbersome to calculate and needs sophisticated laboratory. The MSA and CSI scores although simple and easy to calculate have subjective variables which would increase the observer bias. Hence, there has always been a need of a simple, easy to apply score with quantitative variables so that observer bias can be minimised. The present GCRBS score is an attempt in that direction.

As seen in the previous studies cerebral malaria and acute renal failure are the major contributors to death. Since the neurological status of a cerebral malaria patient can vary from disoriented to stupor to coma, GCS being an easy to calculate quantitative variable has been used to allot a score for cerebral component. Similarly a respiratory rate of more than 24 has been used to identify patients having pulmonary oedema or ARDS which has a high case fatality rate. But contrary to the previous studies jaundice has been found to be an important predictor of mortality in this study. We observed that with the increase in bilirubin level the death rate also rises, more steeply with bilirubin levels >10 mg/dl.

The GCRBS score has a possible score of 0 to 10, higher the score poorer the outcome. 5 parameters are required for its calculation namely **G**CS, **C**reatinine, **R**espiratory rate, **B**ilirubin and **S**ystolic BP (mnemonic GCRBS). Out of these only two (Creatinine and bilirubin) are laboratory parameters and the rest three are clinical parameters which can be easily determined at the bedside. Then a score is allotted to each parameter as shown in Table 2 and their sum gives the GCRBS score. The most important advantage of this scoring system is that all the 5 parameters are to be assessed quantitatively for allotting a score, which would eliminate the possibility of observer bias.

Declarations

Funding : None.

Conflicts of interest: None declared.

Ethical approval: Not required.

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