Original Article

The Malaria Severity Score: a Method for Severity Assessment and Risk Prediction of Hospital Mortality for Falciparum Malaria in Adults

MK Mohapatra*, SP Das**

Abstract

Back ground: There is paucity of research to quantify the severity and to predict the mortality risk of severe falciparum malaria even if it affects multiple organ systems during the course of the disease. Therefore, the aim of the present study is to develop a severity score for assessment of disease severity and risk prediction in adult patients of severe falciparum malaria on the first day of hospitalisation.

Methods: A cohort of 2598 patients of falciparum malaria were enrolled in this study of which 2089 patients were included as developmental sample and 509 patients as validation sample. Physiological variables were analyzed for defining and assessment of severity of organ dysfunction (OD). The severity level and corresponding severity score for each organ dysfunction were determined by logistic regression analysis that took both the relative severity among the organ systems and the degree of severity within an organ system into account. Risk of mortality has been calculated for each score.

Results: Physiological variables defined dysfunction in 7 organ systems with 3 levels of severity (I to III). Neurologic and renal dysfunction had 3 levels of severity. Hematologic, cardiovascular, and respiratory dysfunction had 2 levels of severity where as hepatic and metabolic dysfunction had 1 level of severity. 1,3, and 5 points were assigned to level I,II, and III severity of organ dysfunction respectively. Malaria without any abnormal physiological variables had been considered as no organ failure and assigned 0 score. The cumulative scores in a patient is known as malaria severity score (MSS) that ranged from 0 to 21. Risk of mortality had been calculated for each score.

Conclusion: This prospective study provides an objective tool for assessing severity levels for organ dysfunction and prediction of risk of mortality in severe falciparum malaria which can be used for treatment and research.

It has been observed that no two patients of falciparum malaria are same in severity. The severity varies over time and malaria can affect single or multiple organs with different levels of severity which can be quantified as level I, II, and III. Neurologic and renal dysfunction were the most severe with level III severity, followed by haematologic, cardiovascular, and respiratory dysfunction with level-II severity, as well as hepatic and metabolic dysfunction the least severe with level-I severity. Patient of malaria can be stratified as low, intermediate, and high risk depending on the MSS. With the help of MSS daily risk estimates and recovery time of OD can be determined. ©

Introduction

Research on objective assessment of disease severity and prediction of mortality risk in malaria is lacking even if it frequently develops multiple organ dysfunction (MOD) during the course of illness.[1-3] Therefore, there is paucity of standardized criteria to define organ dysfunction and to estimate risk for mortality objectively in patients of falciparum malaria. Objective risk assessment on the day of admission have been proved very useful for clinical decision making, in evaluating new therapies, in improving quality of treatment, and for proper utilization of resources in various critical conditions like sepsis, acute myocardial infarction etc.[4-6]

"Complicated" and "severe" are the two terms frequently used in relation to falciparum malaria to describe the increasing severity of the disease. Even if the diagnostic features of severe malaria have been set out by WHO, there is no objective criteria to quantify the severity of each complication.[7] Though it is convenient and conventional to describe various complications of falciparum malaria in isolation, clinical reality, however, is that majority of patients

*Professor, Medicine, V.S.S. Medical College and Hospital, Burla, Orissa.
**Retd.Professor Medicine, M.K.C.G. Medical College, Berhampur, Orissa.
Received : 4.12.2008; Accepted : 6.1.2009

present with a wide variety of combined complications leading to multi organ failure. In such a situation assessment of severity of organ dysfunction (complication) is required for risk stratification, prognostication and planning of treatment to arrest the progression of disease, hence mortality.

Therefore, the present study was conducted with an object to develop a system to assess the severity of organ dysfunction in malaria, as well as to estimate patient risk for mortality.

Material And Methods

This prospective study has been undertaken in general wards of two medical College hospitals: M.K.C.G. Medical College and Hospital, Berhampur and V.S.S. Medical College, Burla of Orissa. This study has included the data of patients of our two earlier studies.[8,9] As the objective is to assess severity, therefore all consecutive adult patients (>18 years) of smear positive uncomplicated, complicated, and severe falciparum malaria admitted to Department of Medicine from January 2000 to December 2004 were enrolled in the study. As the coexistence of other diseases may influence the severity assessment therefore the diseases like diabetes mellitus, chronic renal failure, chronic liver disease, rheumatic heart disease, coronary artery disease, sickle cell disease, and associated infections like pneumonia, urinary tract infection and viral hepatitis and pregnancy were excluded from the study.

After exclusion, a total of 2598 patients were enrolled in the study. Of them 2089 (80.4%) patients were selected by random number generation as developmental sample, and the remaining 509 (19.6%) patients as validation sample (Fig. 1).

The diagnosis of malaria was made with detection of asexual forms of P. falciparum from Giemsa stained peripheral blood smear at the time of admission. A medical history was obtained from each participant. Physical examination and laboratory investigations were done in all cases. Blood was collected for estimation of glucose, urea, creatinine, bilirubin, aspartate amino transferase, alanine amino transferase, and for haematological investigations such as haemoglobin, platelet count, and total leukocyte count.

Clinical findings, haematological, and biochemical investigations were entered in a pre designed data base. For the assessment of the degree of severity, 12 different variables were extracted from the data base and grouped according to systems. The variables were analyzed for defining organ dysfunction (OD) and assessment of severity of OD. The worst value of the variables in the first 24 hours period has been considered for the definition as well as assessment of the severity of complications.

Patients were examined and assessed twice daily until full recovery or death. Death or recovery was two outcomes, which were assessed for prediction analysis. All patients were followed up for 1 month after discharge.

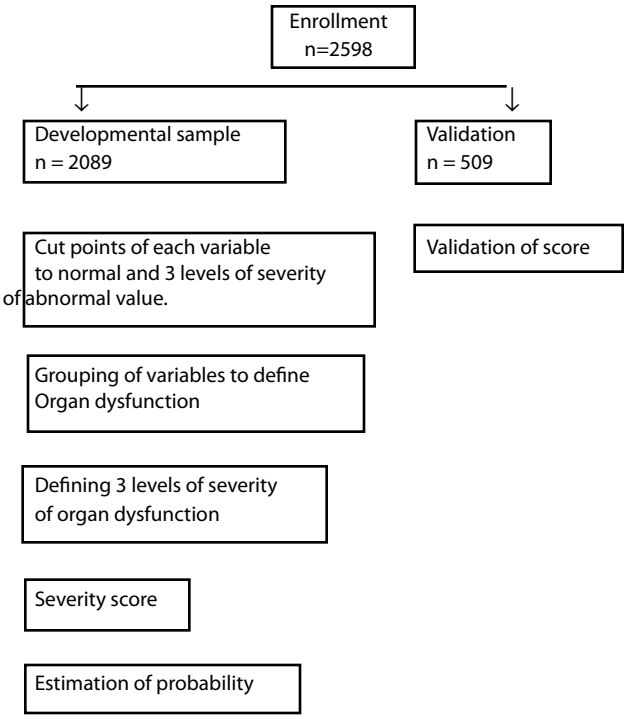

Fig.1: Study plan.

Analyses were performed with the use of SPSS software, version 10.[10] Multiple logistic regression analysis was used to define and assess the severity of OD and to develop the prognostic system. The analysis was made in the following successive steps.

A) Development of MSS by defining the organ dysfunction and determination of severity level with its corresponding score from the variables. For defining the organ dysfunction, the cut points for normal and abnormal and then the cut points that would define the ranges of severity for each variable was determined. The variables were entered simultaneously into a multiple logistic regression model to produce an equation in which each variable had a coefficient (β). The equation takes the form of:

$D=\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X3 \ldots\ldots + \beta_p Xp$. It was a measure of relative weight of the level of severity of the variable. Basing on the observed range of the coefficient, the grade of severity level of each variable was determined in ascending order. Then multiple variables related to one complication were grouped together to define that particular organ dysfunction. For example, blood urea, s.creatinine, and urine output were grouped together to define renal dysfunction. After grouping the variables, relative weight of the group that define a particular OD was obtained from the coefficients (β) of that group. From the coefficients of the group, the level of severity of each organ dysfunction was determined in an increasing order. Thus the range of value of each variable to define each level of severity was determined. The points for each level of severity of every organ dysfunction were calculated by multiplying the average of the coefficient by 10 and rounding to obtain a whole number. Then total severity score was obtained by

summing up the points for each organ involved.

B) Conversion of the score to a probability: To find out the probability of mortality, the total score was used in multiple logistic regression equation in the form of a logit in the multiple logistic regression equation in the form: logit = $\beta_0 + \beta_1$ (Malaria Severity Score). The logit was then converted to a probability of hospital mortality as Pr (y=1|logit)= $e^{logit} / (1+e^{logit})$

C) Assessment of model performance. In the final stage of analysis, the model performance was assessed with Hosmer-Lemeshow goodness-of-fit tests. Area under the receiver operating characteristic (ROC) curve was calculated to evaluate discrimination.

D) Daily risk estimates and recovery time. The scoring has been applied for daily risk estimate, recovery time, and hospital stay.

Results

A cohort of 2598 patients of falciparum malaria was enrolled in this study. Of them, 2089 (80.4%) and 509 (19.6%) patients constituted the developmental and validation sample (Table 1). Dysfunction of 7 major organ systems were derived from the data base and analyzed. The organ systems were neurologic, renal, haematologic, hepatic, respiratory, cardiovascular, and metabolic. Of 2089 patients (developmental sample), there were 261(12.5%), 435 (20.8%), 358(17.1%), 383(18.3%), 358(17.1%), 92(4.4%), 127(6.1%), and 75(3.5%) patients with 0 (no organ), 1, 2, 3, 4, 5, 6, and 7 organ dysfunction respectively. The results according to the successive steps of the analysis are as follows.

All 12 variables were analysed to identify cut points that define normal and abnormal values. Further from the abnormal values, different level of severity for each variable was determined. When the values were within the normal range it was considered as level-0 severity. 3 levels of increasing severity i.e. Level-I, II, and III were identified. 3 levels of increasing severity for the GCS, respiration rate, heart rate, systolic BP, blood urea and serum creatinine as well as 2 levels of severity each for urine output, total leukocyte count, and bilirubin were observed. Platelet count and hypoglycemia had 1 level of severity.The relative weight of each variable was determined by the coefficients (βs) (Table 2). The strength of the association of each variable with mortality was determined from the least to the most severe level. For example, the β for the least severe level of the GCS was 0.50, and it was 2.58 for the most severe level. The bs ranged from 0.22 for the least severe level of bilirubin to 0.52 for the most severe level of bilirubin. Therefore, the least severe level of the GCS had the same association with mortality as the most severe level of bilirubin.

Similar variables related to one system were grouped together to define that particular system. For example urine output, blood urea, and s.creatinine were grouped together to define renal system. Thus OD was defined by using single or multiple variables; neurologic and metabolic dysfunction were defined by a single variable whereas other systems by multiple variables. The range of normal as well as abnormal findings to define OD has been determined (Table 3). Further the range of abnormal vales to define different levels of severity of OD had been determined (Table 4). When the values were within normal range, there was no OD hence 0 level of severity was assigned. Depending on the range of abnormal finding of the variables 3 levels of severity (I, II, and III) were determined (Table 5). The level of severity was not equal for all types of OD. Neurologic and renal dysfunctions were with all the 3 levels of severity and received the maximum of 5 points for the most severe level of dysfunction, hence considered as most severe

Table 1 : Demographics of the patients

Total Nos. of patients = 2598	
MKCG Medical College Hospital = 1500	
VSS Medical College Hospital = 1098	
Age Group (No./ %)*	
18-20	250 (9.6%)
21-30	538 (20.7%)
31-40	648 (24.9%)
41-50	463 (17.8%)
51-60	383 (14.7%)
61-70	233 (8.9%)
>71	83 (3.2%)
Sex: (No./ %)*	
Male – 1700 (65.4%)	
Female – 898 (34.6%)	
Organ Dysfunction (No. (%)* / Death (%)**	
No. complication (uncomplicated)	323 (12.4%) / 0 (0%)
One organ Dysfunction	541 (20.8%) / 56 (10.4%)
Two organ Dysfunction	444 (17.1%) / 63 (14.2%)
Three organ Dysfunction	474 (18.2%) / 121 (25.5%)
Four organ Dysfunction	444 (17.1%) / 119 (26.8%)
Five organ Dysfunction	118 (4.5%) / 81 (68.6%)
Six organ Dysfunction	158 (6.1%) / 139 (87.9%)
Seven organ Dysfunction	096 (3.7%) / 87 (90.2%)

* - % from total No. 2598. ** - % from total of respective group

Table 2 : Co-efficients for levels of severity based on individual variables.

Organ system & variable	0	I	II	III
Neurological				
Glasgow coma scale	0.20	0.50	1.14	1.78
Cardiovascular				
Heart rate	0.24	0.55	1.24	
Syst. Blood Pressure	0.21	0.57	1.12	
Renal				
Urine output	0.32	0.45	1.02	1.54
Creatinine	0.31	0.47	1.08	1.57
Urea	0.44	0.80	1.13	1.7
Respiratory	0.24	0.54	1.02	
Resp.rate				
Hematological				
TLC	0.28	0.69	1.07	
Platelet	0.22	0.7	1.01	
Hb	0.2			
Hepatic	0.22	0.52		
Bilirubin				
Metabolic	0.22	0.7		
Glucose				

Table 3 : Criteria for diagnosis of organ dysfunction in malaria

Criteria	Parameters	
a) General	1) Fever ≥ 101^{0}F	
	2) Presence of asexual form of P. falciparum	
b) Organ Specific	Organ System	Parameters for defining dysfunction
	1. Neurologic	a) Glasgow Coma Scale ≥ 13
	2. Renal (one or more)	a) Urine output < 750ml / 24 hr.
		b) S-creatinine ≥ 1.2 mg/dL
		c) B. Urea ≥ 36.0 mg/ dL
	3. Hepatic	a) S. bilirubin ≥ 2.0 mg/dL
	4. Respiratory	a) Respiratory rate ≥ 30/ minute
	5. Cardiac (one or more)	a) Systolic blood pressure ≤ 90 mm Hg.
		b) Heart rate ≥ 120 beats / minute or < 51.
	6. Metabolic	a) B. Glucose ≤ 60 mg/dL
	7. Hematological (one or more)	a) Hemoglobin < 10.0 gm/dL
		b) Platelet count < 80,000/µL
		c) Total leucocyte count <4000/µL or > 12,000

Table 4 : Range of variables to to assess the level severity of organ dysfunction in malaria

	Parameters of Organ Dysfunction	Range of variables for different Level of Severity Level-0	Level- I	Level-II	Level-III
1	Neurologic				
	GCS Score	14-15	10-13	7-9	0-6
2	Renal				
	B. Urea(mg/dl)	10.0-36.0	37.0-59.0	60.0-119.0	>120.0
	S.Creatinine(mg/dl)	0.6-1.2	1.3-1.9	2.0-4.9	>5.0
	Urine Output(L/day)	0.75 –3.9	0.5-0.75	0.4-0.5	<0.5
3	Cardiovascular				
	Heart rate/min	51-119	120 -139	>140or<51	
	Systolic Blood Pressure (mmHg)	90-160	70-89	41-69	
4	Respiratory				
	Respiration rate/min	20-30	31-40	>41	
5	Haematologic				
	Hb. (gm/dl)	10.0-13.9	7.0-9.9	<7.0	
	TLC (/cmm)	4001-16,000	2001-4000 or10-20000	<2000	
	Platelet (/cmm)	80,000-2,50,000	<80,000		
6	Hepatic				
	S. Bilirubin (mg/dl)	<2.0	≥ 2.0		
7	Metabolic				
	B. Glucose (mg/dl)	60.0-110.0	<60.0		

Table 5 : M.S.S. of each organ dysfunction with different level of severity

Organ Dysfunction and Score	Level of Severity 0	I	II	III	
Neurologic	Score-0	Score-1	Score-3	Score-5	
Renal	Score -0	Score -1	Score -3	Score -5	S
Cardiovascular	Score -0	Score -1	Score -3	x	C
Respiratory	Score -0	Score -1	Score -3	x	O
Hematologic	Score -0	Score -1	Score -3	x	R
Hepatic	Score -0	Score -1	x	x	E
Metabolic	Score -0	Score -1	x	x	

form of organ dysfunction. Cardiovascular, respiratory, and hematologic dysfunctions have level-I and level-II severity and received 3 points for the most severe level of dysfunction, hence moderately severe form of organ dysfunction. Hepatic and metabolic dysfunctions were with 1 level of severity and received 1 point for the most severe level of dysfunction hence considered as least severe form of dysfunction. Thus OD with only one level (I), two levels (I and II), and three levels (I to III) of severity were considered as least, moderate, and most severe dysfunction.

A severity score of 0, 1, 3, and 5 was assigned to 0, I, II, and III level of severity respectively (Table 5). The score may be as low as 1 or as high as 5 for neurologic and renal involvement. For cardiovascular, respiratory, and hematologic system

the lowest and the highest score was 1 and 3. For hepatic and metabolic involvement only 1 score was assigned. The points for each OD are summed to calculate the total malaria severity score (MSS). MSS of 0 indicates no organ dysfunction, whereas MSS of 1 is the lowest level of severity possible for one single organ dysfunction. The maximum score with 21 points can be found when a patient has all 7 organs dysfunction with their highest level of severity.

For an organ dysfunction that has been defined by multiple variables, presence of 1 abnormal variable is enough to assign the full severity point whereas, all the variables must be within normal range to assign 0 point.

The MSS was first calculated for each of the 2089 patients in the developmental sample by summing the points for each organ system. The score was then used to obtain the logit which was then converted to a probability. The goodness-of-fit and area under the ROC curve were excellent in the developmental sample. There was a very good agreement between observed and expected mortality (Hosmer-Lemeshow statistic = 10.8,p=0.21,df=8). The area under the ROC curve in the developmental sample was 0.9. Good model performance was demonstrated among 252 patients in the validation sample. In the validation sample, excellent calibration was indicated by Hosmer-Lemeshow statistics of 9.3, p=0.5, df=10. The overall explanatory power of estimate has been evidenced by r^2 of 0.41 and ROC of 0.91 (Fig. 2). The overall correct classification on the 1st day at a 0.50 predicted risk was 88.5%.

Risk prediction according to severity score: For each level of severity a severity score and subsequently for each value of severity score the probability of hospital mortality had been calculated and presented in Table 6. It has been observed that for each 5 point increase in MSS the mortality has been increased significantly (Odd's ratio 1.19 to 1.51). The patients are grouped as i) Low risk when the score is 5 or less with a risk of less than 40%, ii) Intermediate risk when the score is within 6 to 11 with a risk of 40 to 80%, and iii) High risk when the severity score is 12 or above with mortality risk of 80% or above (p<0.001) (Fig. 3).

Even if the score has been developed from the 1st 24 hours of admission, it has been applied on subsequent days to estimate mortality risk over time for individual patients. In Fig. 4 the daily risk of hospital mortality has been indicated. The organ is said to recover fully when the variables returned to level-0 value. For the organ dysfunction with multiple variables, all the variables should return to normal.

Discussion

The present Malaria Severity Score (MSS) is a physiological scoring system that has been developed to assess the disease severity and to estimate the probability of mortality risk among patients with severe falciparum malaria. The present study also showed that severe malaria is a variable disease causing dysfunction of various organs in different combinations and with variable grades of severity. It can also be applied to estimate the daily risk of mortality and determination of resolution time of OD.

Objective models for prognostication are available for management of sepsis, acute myocardial infarction, acute pancreatitis etc.,[5,6] Attempts have been also been made to assess the severity by taking APACHE-III and multi organ

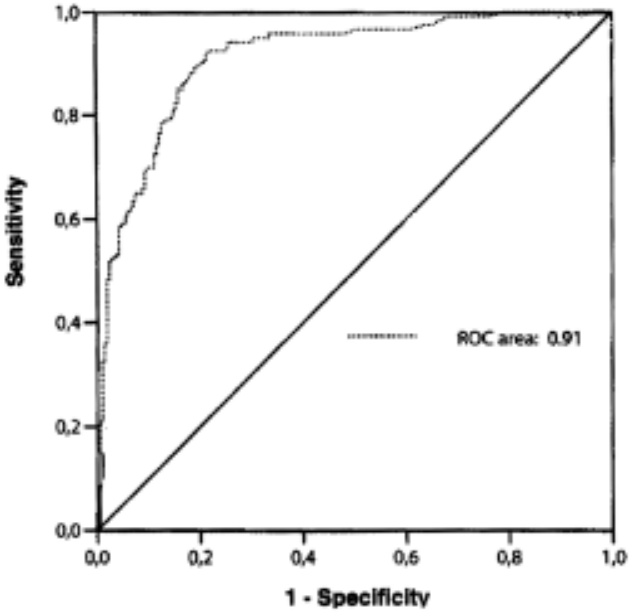

Fig. 2 : ROC curve for prediction of mortality in validation sample.

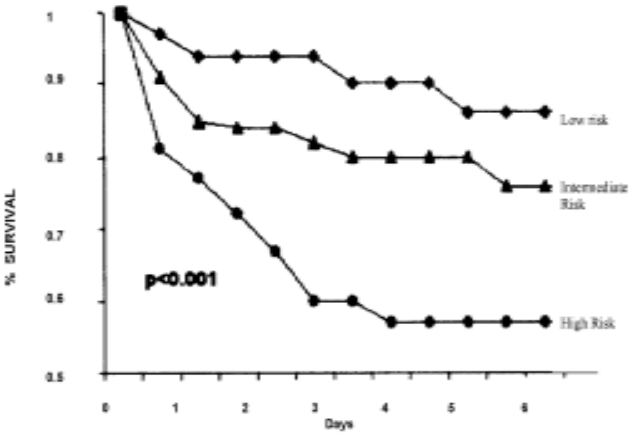

Fig. 3 : Survival Analysis in 3 different risk groups.

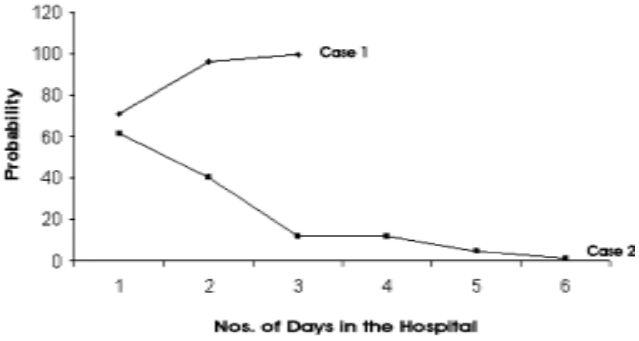

Fig 4: MSS daily risk estimate of 2 patients with severe malaria. Case 1 - Out come - death; Case 2 - Out come - alive

dysfunction score into consideration.[2,11,12] Prognostic scores have also been developed from patients of malaria.[13,14] But in the present study MSS has been developed from a large cohort of patients and risks of mortality have been stratified according to severity of various organ dysfunction.

Organ dysfunction encompasses from mild to severe impairment of physiological functions of a single or multiple organ(s). This concept of organ dysfunction has been frequently applied in sepsis to develop methods to assess the severity and prognosis. Several observations from the study of experimental as well as human cerebral malaria showed that at the cellular level various proinflammatory cytokines and several adhesion molecules play important roles in the pathogenesis of complicated malaria, which is strikingly similar to sepsis.[15] The adhesion molecules mediate the cytoadherence of parasitized RBC (pRBC) to endothelial cells lining the capillaries of brain, heart, lungs, kidney, small intestine, and liver.[2,8,15] Sequestration of pRBC restricts local blood flow to various organs and adversely affects the function of different organ systems almost simultaneously ranging from mild dysfunction to complete organ failure.[2] Therefore, the complications have been defined as respective organ dysfunction as per the criteria given by MODS and APACHE-III system by different authors in their studies.[1,2,11,12] Similarly by simply determining a cut-off value for one or two variables may not able to assess the real severity of malaria when a patient was complicated with multiple complications. It is because different complications of malaria behave differently in their progression, severity, and recovery. It has also been observed that the outcome of patients of severe malaria is better than the outcome of sepsis. Hence, the application of severity of sepsis may not able to assess the real severity of disease. Further, the investigations required for defining an OD in sepsis are available in intensive care units which are not within the reach of majority hospitals where most of the severe malaria patients are being treated. Therefore in this study attempt has been made to define and to assess organ dysfunction from the variables obtained from malaria patients treated in the general ward. As a result the investigations like pH, pCO_2, pO_2, bicarbonate, sodium, and potassium have not been considered for defining OD. Though many organ systems may be affected by falciparum malaria, from our previous studies it was found that 7 major OD occurred commonly in malaria.[8] There fore, in the present study 7 OD with different levels of severity had been defined and validated. Organ dysfunction in malaria can be defined quantitatively by taking different variables into consideration. The use of single or multiple variables for definition of OD has been based on statistical method that analyzed the ranges and relative weights of different variables for defining a particular OD which is similar to sepsis.[5,6] Each OD has been assigned a gradation of severity and allocated a score. Hence, the severity of each OD can be determined quantitatively with the corresponding score and the total score can be obtained by adding the scores of individual OD present in the patient, subsequently that can be converted to a risk estimate of mortality.

Of the 7 OD neurologic and renal dysfunctions were the most severe with the maximum score of 5 points. Pulmonary, cardiac, and haematologic dysfunctions received 3 points for the most severe level of dysfunction and considered as moderately severe OD. Hepatic and metabolic dysfunction received 1 point each, hence considered as least severe OD. However, in severe sepsis, it had been observed that neurologic, renal, cardiovascular, and respiratory dysfunctions were the most severe, while hepatic and haematologic dysfunctions were less severe.[16] The severity score varied depending upon the involved organs and the level of severity of the respective organ. It can be as low as 1 or as high as 5 with 1 organ dysfunction, and as low as 7 or as high as 21 with all 7 organs in dysfunction. There are several clinical situations by which a patient might receive high severity score. Either a patient has involvement of several organs with low (level-I) to moderate (level-II) level of dysfunction or few organs with severe level (level-III) of dysfinction. In any such clinical situation the mortality risk is very high.

There is a score for each organ dysfunction according to its severity level and for each score there is also a probability of mortality. Hence, each score can be translated into a corresponding range of estimated probability of mortality. The probability of mortality increases steeply after the severity score of 5; for each point of rise in score the mortality increased approximately by 10.0%.After the score of 12, the probability of mortality was more than 80.0%.

For example, if a patient had neurological, renal, and cardiovascular involvement at its most severe level of dysfunction, then the score would be 13 (5+5+3) and the probability of mortality would be 88.8%. Similarly if a patient had involvement of 3 organ systems at their least severe level of dysfunction, the score would be 3 regardless of which organs were involved and the corresponding mortality would be 4.8%. If a patient was admitted only with renal dysfunction without any other organ dysfunction, that patient had 1 organ dysfunction and would be scored according to the severity of dysfunction. If such a patient had neurological involvement, the patient would have additional neurological dysfunction and scoring would be done according to the severity.

The present MSS has many advantages. Firstly, it has a great potential as a tool to assess the real severity and risk stratification of complications. Hence, clinicians and physicians engaged in treatment and research in malaria can stratify risk to make decisions in treatment to improve quality of patient care and outcome evaluation. Comparison between different groups can be done in a quantitative manner. Secondly, it can be used to predict the outcome easily because for each score there is also a probability of mortality which has already been calculated. Hence, by knowing the score one can estimate the risk. Thirdly, multiple organ dysfunction is not necessary for the

application of MSS. Because it grades organ dysfunctions in such a way that the severity can be quantified whether single or multiple organs are involved. Fourthly, it can be used for daily risk estimate and to determine the resolution time of each complication.

Like other models of prognostication, the potential criticisms of the present study are as follows: 1) The MSS has been calibrated for general ward in one geographical area. Our choice was to use general ward mortality because this condition is mostly encountered in the areas where it is impractical to treat all the cases of severe malaria in intensive care unit. 2) It may be argued that MSS is best used to describe the severity of illness rather than to estimate the risk of mortality. Since other components such as parasitaemia and therapeutic intervention can affect the severity and outcome. But it is the physiological markers that are most objectively quantifiable. Therefore, similar to sepsis only physiological parameters have been taken into consideration. Severity describes the gradation of dysfunction whereas risk quantifies the severity into an estimate of the probability of mortality. The later can be used and tested objectively by comparing it with the observed outcome. 3) Other co-morbid conditions are not taken into consideration in the present study. In spite of these limitations this study assessed the severity of complications (organ dysfunction) in severe malaria in a large cohort of patients, which can be useful for treatment and research. However, it should be applied in the face of changing case mix and intensive care units for further evaluation.

Appendix 1

Guide to MSS Risk Estimates:

To calculate the severity of malaria score one has to take the organ system (s) involved, then the level of severity with the help of Table-4 and then the corresponding MSS (Table 5). Then the score for each organ dysfunction will be added to know the final score. The probability of mortality for the score can be known from Table 6.

The procedure for estimating the hospital risk of mortality of severe malaria entails the following steps:

Step-1: After the confirmation of the diagnosis of malaria general examination and biochemical investigations will be done within 24 hours of admission as per Table 2.

Step-2: Determination of dysfunction: From the findings the organ dysfunctions will be determined.

Step-3: From the values, severity level and score will be determined. For an organ dysfunction that has been defined by multiple variables, presence of 1 abnormal variable is enough to assign the full severity point whereas, all the variables must be within normal range to assign 0 point.

Step-4: From the score risk of mortality can be determined.

Example-1:- S.M. 23 years male, admitted with history of fever for 5 days, loss of consciousness for 2 days. On examination he had GCS of 5, Pulse 100/mt, Blood Pressure-120/84 mm of Hg., Respiration rate-24/mt, s.bilirubin-4.0mg/dl, B.glucose-90mg/dl, B.urea-32mg/dl, s.creatinine-1.2mg/dl, urine output - 1200 ml/24hrs., Hb.- 6.5gm/dl, TLC-12,000/cmm, Platelet count 82,000/cmm.

Organs involved- Neurologic, Hepatic, and Haematologic

Severity level: Neurologic: level-III, Hepatic: level- I, Haematologic: level -I

Score- 5+1+1=7

Probability of mortality – 31.1%

Example-2: R.B., 29 years female, admitted with history of fever for 2 days, loss of consciousness for 1 day. On examination she had GCS of 5, Pulse 110/mt, Blood Pressure-110/80 mm of Hg., Respiration rate-24/mt, s.bilirubin-5.0mg/dl, B.glucose-80mg/dl, B.urea-62mg/dl, s.creatinine-4.2mg/dl, urine output - 1000 ml/24hrs., Hb.- 4.5gm/dl, TLC-11,000/cmm, Platelet count 1,82,000/cmm.

Organs involved- Neurologic, Hepatic, Renal, and Haematologic

Severity grades: Neurologic: level-III, Renal: level-II, Hepatic: level-I, Haematologic: level-I

Score- 5+3+1+1=10

Probability of mortality – 61.7%

References

1. Krishnan A, Karnad DR. Severe falciparum malaria: an important cause of multiple organ failure in Indian intensive care unit patients. Crit Care Med 2003;31:2278-84.
2. Helbok R, Dent w, Nacher P, Lackner S, et al. The use of the multi-organ-dysfunction score to discriminate different levels of severity in severe and complicated Plasmodium falciparum malaria, Am j Trop Med Hyg 2005;72:150-4.

Table 6 : M.S.S. and probability of mortality

Severity of malaria score	Probability of mortality
0	1.2
1	3.1
2	4.8
3	7.5
4	10.5
5	12.0
6	21.1
7	31.1
8	40.1
9	51.8
10	61.7
11	70.8
12	81.8
13	88.8
14	92.0
15	94.6
16	96.1
17	97.2
18	98.5
19	99.2
20	99.5
21	99.7

3. Mohapatra MK, Sethi G, Das SP, Pattnaik SR. Incidence, outcome and predictive factors of falciparum malaria with multi organ failure. J Asso Phys Ind 2001;49:149.
4. Clinical guideline: Part I: Guidelines for risk stratification after myocardial infarction. Annals Int Med 1997;126:556-60.
5. Knaus WA, Wagner DP, Draper EA, Zimmerman JE, et al. The APACHE III prognostic system-Risk prediction of hospital mortality for critically ill hospitalized adults. Chest 1991;100:1619-36.
6. LeGall J, Klar J, Lemeshow S, Saulnier F, et al. The logistic organ dysfunction system: a new way to assess organ dysfunction in the intensive care unit. J Am Med Asso 1996;276:802-10.
7. World Health Organization. Severe falciparum malaria, Trans Roy Soc Trop Med & Hyg 2000;94: supplement 1.1-90.
8. Mohaptra MK. The natural history of complicated falciparum malaria-a prospective study, J Asso Phys Ind 2006;54:848-53.
9. Mohapatra MK, Das SP, Das MC, Misra SS. Clinical profile and outcome prediction of severe falciparum malaria with multiple organ dysfunction syndrome. International Conference on Malaria, New Delhi, 2005:59
10. SPSS Base System user's Guide. 4th Edition, SPSS Inc, Chicago, 1991.
11. Lichtman R, Mohrcken S, Engelbrecht M, Bigalke M. Pathophysiology of severe forms of falciparum malaria. Crit Care Med 1990;18:666-8.
12. Helbok R, Dent W, Nacher M, Treeprasertsuk S, et al. Use of the multi organ dysfunction score as a tool to discriminate different levels of severity in uncomplicated Plasmodium falciparum malaria. Am J Trop Med Hyg 2003;68:372-75.
13. Mishra SK, Panigrahi P, Mishra R, Mohanty S. Prediction of outcome in adults with severe falciparum malaria-a new scoring system. Malaria Journal 2007;6:24-28.
14. Mohapatra M K. The natural history and assessment of severity of organ dysfunction in complicated falciparum malaria. International Conference on Malaria, New Delhi, 2005: 34.
15. Lou J., Lucas R., Grau GE. Pathogenesis of cerebral malaria: recent experimental data and possible applications for humans. Clin Micro Rev 2001;14:810-20.
16. Fagon JY, Chastre J, Novara A, Medioni P, Gilbert C. Characterization of intensive care unit patients using a model based on the presence or absence of organ dysfunction and/or infection: the ODIN model. Intensive Care Med 1993;19:137-44.