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A Tertiary Teaching Hospital's Evaluation of Sequential Organ Failure Assessment (SOFA) Scoring as a Tool for Reporting and Projecting Results in Critically Ill Obstetric Patients

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ABSTRACT
Severe maternal morbidity (SMM) is a continuous condition involving organ dysfunction, with higher maternal mortality rates due to poor health services and pregnancy risks. This study aims to observe changes in daily SOFA scores of critically ill patients in an obstetric ICU, study their clinical course and evaluate if SOFA scores can predict their outcomes. To determine the predictive and discriminative abilities of the Sequential Organ Failure Assessment (SOFA) scores to monitor and predict outcomes in pregnant women with severe obstetric morbidity who were admitted to the Obstetric Intensive Care Unit (ICU) in our tertiary hospital. It was an observational study. This study was conducted at the Obstetric ICU in Department of Obstetrics and Gynecology, Calcutta National Medical College and Hospital, Kolkata. The study covered over a period of One year (July 2021 to June 2022). Numbers of the patients taken for the study were 100. The correlation between SOFA scores and mortality through the ROC curve. Correlation between SOFA score and mortality is found to be very significant. SOFA scoring is a valuable method for monitoring patients with severe maternal morbidity in Obstetric ICUs, with scores of 7 and above providing accurate mortality predictions and prognostic information.

INTRODUCTION

Severe complications in 15% of pregnancies result in 529.000 maternal deaths annually worldwide, arising from pregnancy risks and poor-quality health services. Ensuring equitable access to basic and emergency skilled care, early recognition and treatment of potentially life-threatening conditions is critical for saving the lives of mothers and their newborns. Severe maternal morbidity (SMM) is an ongoing condition that involves organ dysfunction, which is a continuous, dynamic process of alterations in organ function. Different patient populations develop different patterns of organ dysfunction and studies have reported that the degree of organ dysfunction, the number of failing organs and the duration of the condition are variables directly related to higher maternal mortality. Severe maternal morbidity (SMM) has different definitions in different setups and countries, but the Severe Morbidity indicators according to ICD-10 codes during delivery hospitalizations are used for this study. The maternal death rate in West Bengal is currently 101 per 100,000 live births (2014-16), due to pregnancy complications and sub-optimal quality of health and referral services. In our tertiary care teaching hospital, the maternal death ratio in 2020 was 335 per 100,000 live births. Previous investigators have identified a link between the number of dysfunctional organs and both short-term and long-term mortality among emergency department patients with infection. However, these scores have been mostly developed by studying non-pregnant patients in general ICUs. The Sequential Organ Failure Assessment (SOFA) score is a simple and objective score that allows for calculation of both the number and severity of organ dysfunction in six organ systems (respiratory, coagulator, liver, cardiovascular, renal and neurologic). The objectives of this study are to observe the alteration in daily SOFA scores of critical patients in our obstetric ICU, study the subsequent clinical course and outcomes of these mothers and evaluate whether SOFA scores can be used to predict the ultimate outcomes of these critically ill mothers. To determine the predictive and discriminative abilities of the Sequential Organ Failure Assessment (SOFA) scores to monitor and predict outcomes in pregnant women with severe obstetric morbidity who were admitted to the Obstetric Intensive Care Unit (ICU) in our tertiary hospital.

MATERIALS AND METHODS

Study Area: Obstetric ICU in Department of Obstetrics and Gynecology, Calcutta National Medical College and Hospital, Kolkata.

Study Type: It was an observational study.

Study Design: It was a longitudinal, prospective study.

Study Period: One year (July 2021 to June 2022).

Sample Size: 100 consecutive patients with severe maternal morbidity admitted in our Obstetric ICU.

Study Population: All patients admitted in Obstetric ICU of Calcutta National Medical College Hospital, Kolkata.

Sample Technique: Purposive sampling was done to select 100 consecutive ICU patients who fulfil the inclusion criteria of Severe Maternal Morbidity and do not have any exclusion criteria.

Formula for Sample Size Calculation: About 10 patients are admitted in Obstetric ICU with diagnoses which fulfil the criteria for SMM each month. Based on this, we estimated a sample size of 100.

Methods: The study was carried out on 100 women admitted in Obstetric ICU who fulfilled the following criteria:

Inclusion Criteria: Mothers (antepartum or postpartum) who are admitted in ICU with any of the following diagnoses, or who undergo any of the following procedures:

- Acute Myocardial infarction.
- Aneurysm.
- Acute Renal Failure.
- Adult respiratory distress syndrome.
- Amniotic fluid embolism.
- Cardiac arrest/ventricular fibrillation.
- Conversion of cardiac rhythm.
- Disseminated intra vascular coagulation.
- Eclampsia (including HELP syndrome).
- Heart failure/arrest during surgery or procedure.
- Puerperal cerebrovascular disorders.
- Pulmonary edema/Acute heart failure.
- Severe anaesthesia complications.
- Sepsis.
- Shock.
- Sickle cell disease with crisis.
- Air and thrombotic embolism.
- Blood products transfusion (provided used to correct hemodynamic instability or gross hematological abnormalities).
- Hysterectomy (peripatus).
- Temporary tracheotomy.
- Ventilation.

Exclusion Criteria:

- Non-pregnant patients or postnatal patients beyond 42 days of delivery.
- Patients admitted in ICU for observation in anticipation of their condition worsening.
- Patients admitted with mild infections with no evidence of systemic sepsis.

- Patients who expired within 24 hours of admission in ICU.
- Patients given transfusion of blood products for correction of chronic anaemia or pre-existing hematological abnormalities.

Study Variables:

Baseline Variables:

- Age Parity.
- Obstetric history.
- Number of antenatal visits.
- Referral status-whether referred in from peripheral facility and duration of journey Indication for admission in ICU.

SOFA Scoring: (As per Proforma) at admission in ICU Daily SOFA scores.

Interventions Needed: The need for following interventions was studied:

- Higher antibiotics.
- BIPAP/CPAP.
- Mechanical ventilation.
- Blood product transfusion.
- Vasoactive drugs infusion.
- CPR.
- Hematolysis.

Outcomes:

- Discharge from hospital in good condition.
- Discharge from hospital with residual morbidity.
- Transfer to other department or facility for management of residual organ dysfunction.
- Maternal Death.
- Duration of ICU stay.
- Duration of hospital stay.

RESULTS AND DISCUSSIONS

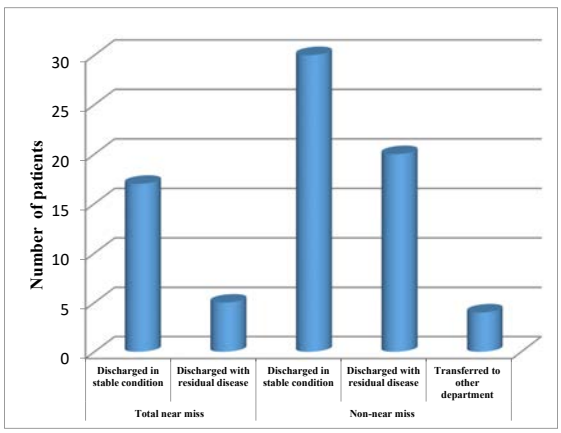

Fig. 1: Outcomes Among Non-Near Miss Patients

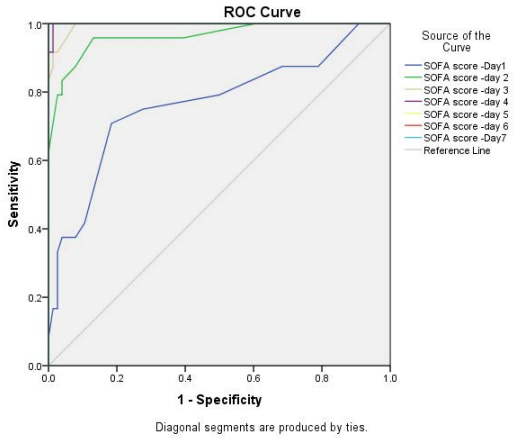

Fig. 2: Correlation Between SOFA Scores and Mortality

PaO2/FiO2 ratio is used for scoring in SOFA. 70% of the patients had PaO2/FiO2 ratio above 400 on day 1, which gives SOFA score point of 0. 21% had PaO2/FiO2 ratio between 300 and 400 (SOFA score point 1), 6% had ratio between 200 and 300 (SOFA score point 2) and only 3% had poor PaO2/FiO2 ratio of <=100. None had scores between 100 and 200 on Day 1. As represented in the Table above and the Figure below, on Day 7 a larger number of patients had very poor PaO2/FiO2 ratio of <=100 (18%), while those with ratios between 100 and 200 was 5% and those with ratio between 300 and 400 was 1%. 76% patients had good scores >400 on Day 7. None had scores between 200 and 300 on Day 7. Coagulation factor is scored from Platelets count in the SOFA scoring system. As shown in Table 10 above, only 25 patients had normal platelet counts on Day 1 and 24 had normal counts above 1.5 lakhs/cumm on Day 7. 49 patients had platelet count below 1 lakh/cumm on Day 1 and the number remained 48 on Day 7. More severe thrombocytopenia with Platelet count $\leq$50,000/cumm was present in 14 patients on Day 1 and 12 patients on Day 7. Liver function, as indicated by serum bilirubin level, was normal in 44 patients on Day 1 and marginally impaired in 18. By Day 7, 55 patients had normal Liver function. Hyperbilirubinemia ($\geq$2 mg/dL) was present in 38 patients on Day 1, with 6 having high levels above 6 mg/dL, of whom 4 patients had serum bilirubin levels more than 12 mg/dL. By Day 7, the numbers had improved to 29 having hyperbilirubinemia, but of these patients 11 had high bilirubin levels above 6 mg/dL, with 2 having very high level $\geq$12 mg/dL. It is evident that on Day 1, 24% of the patients were hypotensive, of whom 10 were put on noradrenaline infusion. By Day 7, 29% of the patients had become hypotensive and 19 were on noradrenaline infusion, including 14 on high dose of

Table 1: Individual Organ Function Scores

		Frequency-Day1	Frequency-Day7	p value
Respiration (PaO2/FiO2	≤100	3	18	< .00001
	200-300	6	5	
	300-400	21	1	
	>400	70	76	
	Total	100	100	
Platelet count/cumm	>1.5 lakhs	25	24	< .00001
	1.01-1.5 lakhs	26	28	
	51,000-1 lakh	35	36	
	21,000-50,000	12	10	
	Total	100	100	
	≤20,000	2	2	
Liver Function (Bilirubin)	<1.2	44	55	< .00001
	1.2-1.9	18	15	
	2.0-5.9	32	18	
	6-11.9	2	9	
	>12	4	2	
	Total	100	100	
MAP or Vasopressor infusion rate	MAP >70 mm Hg	76	69	< .00001
	MAP <70 mm Hg	14	12	
	Dopamine infusion =5 µg/kg/min OR any Dobutamine	0	0	
	Norad/Ad <0.1 µg/kg/min OR Dopamine >5 µg/kg/min	9	5	
	Norad/Ad >0.1 µg/kg/min OR Dopamine >15 µg/kg/min	1	14	
	Total	100	100	
Glasgow Coma Scale	15	62	77	< .00001
	13-14	14	0	
	10-12	15	0	
	6-9	5	3	
	<6	4	20	
	Total	100	100	
Serum Creatinine mg/dL	<1.2	65	61	< .00001
	1.2- 1.9	23	16	
	2.0-3.4	9	11	
	3.5-4.9	3	4	
	≥5	0	8	
	Total	100	100	

Table 2: Causes of Maternal Deaths

Maternal deaths	Cause of death	No of deaths	Percentage
	Multiorgan dysfunction syndrome	7	29
	Hemorrhagic shock	4	16.6
	Eclamptic coma	2	8.3
	Hepatorenal syndrome	2	8.3
	Refractory acidosis	2	8.3
	Renal failure	2	8.3
	Septic shock	1	4.1
	Cerebrovascular accident	1	4.1
	Choriocarcinoma	1	4.1
	Diabetic ketoacidosis	1	4.1
	Disseminated intravascular coagulation	1	4.1
	Total	24	100

ionotrope. The Glasgow Coma Scale (GCS) is used to score the Neurological system, mainly the Central Nervous System (CNS), in SOFA scoring. Among our study patients, 62 patients had fully normal neurological function with GCS 15 on Day 1, 29 patients had impaired consciousness with scores between 10 and 14, while 9 patients had scores below 9, of whom 4 had very poor GCS score below 6. By Day 7, 77 patients were found to have normal neurological function, but 20 patients were completely unconscious with GCS below 6 and 3 patients had score between 6 and 9. In the SOFA scoring system, serum creatinine level is used to score renal function. In our study, 65 patients had normal renal function with serum creatinine <1.2 mg/dL on Day 1, 23 patients had serum creatinine levels between 1.2 and 1.9 mg/dL, while 12 had serum creatinine level above 2 mg/dL, though none had levels above 5 mg/dL. By Day 7, however, only 61 patients had normal renal function, serum creatinine levels were between 1.2 and 1.9 mg/dL in 16 patients, while the remaining 23 patients had levels above 2 mg/dL. Among these, 8 patients had serum creatinine above 5 mg/dL. Overall, 6 patients in our study required haemodialysis. The above table shows the causes of maternal death in our 24 study patients. 7 of the deaths (29%) were due to Multi-organ dysfunction syndrome as an end-stage of various disease processes, hemorrhagic shock resulted in 4 deaths (16.6%), there were 2 deaths each due to eclamptic coma, hepatorenal syndrome, respiratory acidosis and renal failure (8.3% each), while remaining 5 mothers died due to septic shock, cerebrovascular accident, choriocarcinoma, diabetic ketoacidosis and DIC (4.1% each). Among the 22 Maternal Near Miss

cases, 17 were discharged in healthy condition, while 5 (23%) had residual diseases like hypertension, renal or hepatic impairment at the time of discharge. The 54 mothers who did not qualify for Near Miss, 30 mothers (56%) were discharged in healthy condition, 20 (37%) had residual disease and 4 mothers (7%) had to be transferred to other departments of the hospital for residual organ impairment. This is also depicted in (fig. 2) below. The correlation between SOFA scores and mortality through the ROC curve. Correlation between SOFA score and mortality is found to be very significant. Mean SOFA scores of Day 5, Day 6 and Day 7, which are under curve=1,were found to be the most predictive about the outcome of the patients in ICU.SOFA score of 7 and above with increasing trend had the most accurate predictive value for mortality. Interpretation of the area under the ROC curve showed that the performance of the total SOFA score was excellent for day 7 (AUC 1.0., 95% CI: 1.0-1.0) in predicting the outcome of the patients in this study, while for day 1 AUC was 0.766 (95% CI:0.644-0.888).

Maternal death is a significant health indicator and near-miss cases evaluate obstetric health care quality. Early recognition of complications and referral to higher centers are crucial for reducing maternal morbidity and mortality. Access to safe, affordable care is also essential. Predicting severe morbidity and mortality in obstetric patients is challenging due to different organ dysfunction patterns. An ideal scoring system should help predict mortality, quantify illness severity and predict treatment success. A study conducted in a tertiary care center found that the total SOFA score performed well, suggesting its utility in ICU cases. High scores suggest severe organ/system dysfunction. In present case study, we enrolled 100 consecutive obstetric patients who were admitted in obstetric ICU during the study period. Comparison of the outcome of our study with the various literatures will help us to enhance the knowledge and future management. SOFA scoring utilizes six markers to score the dysfunction of six different organ systems. For respiratory system, the marker PaO2/FiO2 was normal in 70% of the patients on day 1 and in 76% by day 7 of ICU stay. However, in the patients in whom respiratory system was affected, as many as 18 had very poor PaO2/FiO2 of <100 by day 7 of ICU stay. The study found that the coagulation system was the most affected in obstetric patients, with only 25% having normal platelet counts on the first day of ICU admission. Thrombocytopenia, a complication of various obstetric disorders, was found in 12-14% of patients. Despite transfusions, there was only marginal improvement in mean platelet count during their seven-day ICU stay. Liver function is scored from serum bilirubin level and in our study 44% had normal bilirubin level on admission in ICU, which improved to 56% by the seventh day of ICU stay. However, the sickest patients had worsening of liver function as indicated by high bilirubin levels above 6 mg/dL in 11% of the patients and a rise in the mean bilirubin levels of the group between first and seventh day of ICU stay.

Cardiovascular affection as adjudged by mean arterial pressure and/or vasopressor use was affected in 24% of our study group on day of ICU admission. By seventh day, 29% of the patients had become hypotensive and 19% were on ionotrope infusion, including 14% on high dose of ionotrope, though overall mean of MAP improved in the whole cohort over time. As evident from GCS scoring, abnormal neurological function was present in as many as 38% patients at admission in ICU, with majority (29%) having GCS between 10 and 14. By the seventh day after admission, neurological function had become normal in most patients (77%), but 23% remained unconscious with poor GCS below 6 in as many as 20%.

Finally, renal function was assessed using serum creatinine levels. 65% patients had normal renal function at admission, but renal function of many of these patients subsequently deteriorated due to their disease processes. By seventh day of ICU stay, only 61% had normal creatinine levels, with majority (27%) having serum creatinine levels between 1.2 and 3.4 mg/dL. 12% patients had serum creatinine levels above 3.5 mg/dL on seventh day and nine patients in our study group required haemodialysis. Thus, frequency of organ affection noted in our study was with coagulation system most affected in almost three-fourths of patients, followed by liver function in about half. Renal function, cardiovascular function and CNS were affected in about a third of our patients and respiratory system in about a quarter of them. **Ray**[1] performed a similar study in a tertiary centre in West Bengal in 2020 and found that respiratory system was involved in majority of the women followed by the cardiovascular and renal system. 99% of the patients in our study had one or more organ system involvement and only one patient referred in as puerperal sepsis had none of the six organ systems involved despite their obstetric complication. Most patients (25%) had three organ system involvements, while 21% of the patients had one organ system involved and 20% had two systems involvement. 11% of the critically ill patients had four organ system involvements, five organs were involved in 7% patients and all six organ systems were involved in 15% of our study patients. These findings are similar to those of **Oliveira-Neto**[2] in 2011. In that study organ dysfunction and/or failure diagnosed according to maximum SOFA score was found in 61.1% of admissions to the ICU. They also noted significant

correlation was also found between the number of failed organs and mortality, with mortality varying from 0.2% in women with no organ failure to 85.7% in those in whom failure of three or more organs occurred. The next objective of our study was to note the different life saving interventions required in the severely ill obstetric patients. Most (81%) patients in our study required only various medical interventions, apart from the interventions required for delivery. This included mechanical ventilation in 21%, haemodialysis in 9% and ionotropic support in 22% of the patients in our study. Additional surgical interventions were necessary in 19% of our study patients and included peripartum hysterectomy (4%), drainage of haematomas (3%), laparotomy for ruptured ectopic pregnancy (4%) and evacuation of septic/incomplete abortion (4%). When studied according to level of intervention, 12% of our patients required only observation and conservative (Level 1) management. Most patients (57%) required Level 2 interventions like higher IV antibiotics, oxygen via NRBM, Magnesium sulphate administration and blood product transfusions. 31% of our study patients required Level 3 interventions. In our study it was found that need for ventilatory support increased for patients with SOFA score of 16 or higher. The need for inotropic support was around 90% at SOFA score above 12, which rose to 100% for score above 21. **Vaghasia**[3] also used SOFA Score to predict mortality among patients admitted in obstetric ICU at a tertiary care Institution in India and published their findings in 2019.Similar to our results, their study also concluded that requirement for assisted ventilation increased from approximately 22% in patients with SOFA score between 6 and 10 to nearly 90% and more in patients with SOFA score of 16 or higher. The need for inotropic support was around 90% between SOFA score of 11-20, which rose to 100% for score above 21. The rise in need for transfusion was, however, not that acute with rise in the SOFA score in their study. Final objective of our study was to correlate SOFA scoring with final outcome and to note its predictive value for maternal death. Hence, we analyzed the SOFA scores among the 76 survivors and 24 cases of maternal deaths. In our study, SOFA score of 7 and above with increasing trend was found to have most accurate predictive value for mortality. In relationship with SOFA score and survival, it was found that the patients who survived had a decreasing trend of mean SOFA score from day 1 (3.56) to day 7 (1.9)while it was an increasing trend of scores among mothers who ultimately died, from Day 1 score of 7.08-Day 7 score of 16.8, respectively. Thus, it is evident that the trend of increasing SOFA scores after Day 1 indicates higher probability of fatality on subsequent days. **Srivastava**[4,5] in 2021 performed a similar study at a tertiary centre at Lucknow, India. The researchers found that mortality between 7.7% in patients with maximum SOFA score of ≤2 to >93% in patients with maximum SOFA score of >18. Mean total maximum SOFA score was higher in non survivors than in survivors [20.50±1.84 vs 7.47±4.58, P<0.001]. They also found that of all the patients admitted, 27 (23%) had no organ dysfunction (SOFA score ≤) and failure of one or more organ/system (SOFA score ≥3) occurred in 94 (76.85%) of patients. In the present study, rather than maximum SOFA score, SOFA score of day 5,day 6 and day 7, which had area under curve=1, were found to be the most predictive about the outcome of the patients in ICU. Thus, patients responding to treatment with SOFA scores showing improvement by day 5-7 were more likely to survive than those whose scores continued to worsen. **Jain**[6] in 2016 performed a study among ICU patients in another tertiary care hospital noted that the total SOFA scores on each day were correlated with survival. Total SOFA scores of day 1, 3 and 5, correlated significantly with survival, but those of day 7 and day 9 did not. In the present study it was found that the mean SOFA score for each subject correlated significantly with mortality. The maximum SOFA score for each subject also showed significant correlation with survival. The duration of stay in the ICU did not have a significant correlation with the SOFA scores. The study by **Vaghasia**[3] also found that Mortality among patients increased with increase in SOFA score from nil mortality among patients with SOFA score between 5 and 10 to >85% among patients with SOFA score of 16 or higher. The most consistent observation of our study is higher the SOFA score higher the mortality. In this study, seven days SOFA scores were taken to evaluate and predict the outcome of the patients and it was found that in case of the patients who did not survive, daily mean SOFA score progressively increased with time, average SOFA score on day 1 being 4.46 and on day 7 being 5.55. Our findings are compared with other similar studies in the following two tables.

CONCLUSION

We conclude that SOFA scoring is an excellent method of monitoring of patients admitted in Obstetric ICUs with severe maternal morbidity. We find that score of 7 and above on day of admission with increasing trend has most accurate predictive value for mortality and is the most useful parameter for Centre considering referral. For prognostic scoring, SOFA scores of fifth, sixth or seventh day is most useful for predicting ultimate patient outcomes.

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