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Applicability of WHO Maternal Severity Score (MSS) and Maternal Severity Index (MSI) Model to predict the maternal outcome in near miss obstetric patients: a prospective observational study

Rubina Pandit[1,2] · Vanita Jain[1] · Rashmi Bagga[1] · Pooja Sikka[1] · Kajal Jain[3]

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Abstract

Objective To assess the applicability of WHO Maternal Severity Score (MSS) and Maternal Severity Index (MSI) Model in near miss (NM) obstetric patients

Methods It was a prospective observational study conducted at a tertiary health care center from July 2015 to Feb 2016. All patients fulfilling one or more WHO NM criteria were included. MSS and MSI were calculated for all NM patients on admission. They were then followed up till the final outcome (NM or death). Each NM parameter, system-wise MSS, total MSS and MSI were then associated with the final outcome.

Results Of 4822 patients, 1739 had potentially life-threatening conditions of which 174 were identified as NM. The average MSS and MSI of patients who remained NM was 4.41 and 11.67%, respectively, and those who died was 9.47 and 58.16%, respectively. Both were found to be significantly associated with the outcome ($p < 0.001$). MSI had good accuracy for maternal death prediction in women with markers of organ dysfunction (AUROC – 0.838 [95% CI 0.766–0.910]). However, of 25 NM criteria, only 17 NM criteria and 3 system dysfunctions (cardiovascular, respiratory and neurological) were found to associate significantly with the outcome.

Conclusion MSS and MSI act as good prognostic tools to assess the severity of maternal complications and estimate the probability of death in NM patients. As all NM parameters are not equally predictive of severity of maternal morbidity, different scores per NM parameter and system should be assigned while calculating MSS for better prognostication.

Keywords Near miss · Maternal Severity Score · Maternal Severity Index

Objective

Mortality indicators are not true reflection of health status of females and do not provide adequate information to avert maternal deaths. For every woman who dies, 20 more women experience acute and chronic complications [1]. A more accurate and reliable assessment can be made by taking into consideration those pregnant females who witnessed serious life-threatening complications but still managed to survive. Thus the idea of Severe Acute Maternal Morbidity (SAMM)/Near Miss (NM) is more suitable for the current health care system [2]. Maternal near miss is a more valuable indicator for analysis of obstetric care than maternal mortality [3].

Maternal NM case is defined as "A woman who nearly died but survived a complication that occurred during pregnancy, childbirth, or within 42 days of termination of pregnancy" [4].

Traditional models developed for risk stratification usually overestimate the risk of mortality among pregnant females, thereby hindering the analysis of performance of care provided [5]. In 2008, the World Health Organization (WHO) had developed a maternal NM definition and formulated standard criteria for identifying women presenting with any of the life-threatening complications [4]. Establishment

✉ Rubina Pandit
reebapandit@gmail.com

1 Department of Obstetrics and Gynecology, Postgraduate Institute of Medical Education and Research, Chandigarh 160011, India

2 Department of Reproductive Medicine, Cloudnine Hospital, Bangalore, India

3 Department of Anesthesia, Postgraduate Institute of Medical Education and Research, Chandigarh, India

of such criteria leads to detection of maximum number of pregnant women with any complication arising during pregnancy which otherwise can adversely affect maternal heath if left untreated.

Maternal Severity Score (MSS) equals to the total number of markers of organ dysfunction present in the patient which correlates with the severity of maternal condition. Maternal Severity Index (MSI) estimates the death probability of women presenting with complications related to pregnancy [6]. These two scores help in assessing NM patients in the spectrum of severity, so that a decision of any immediate intervention required can be made at the right time. Not enough data is available to validate the accuracy of these scores in prognosticating NM patients. Moreover, there is paucity of literature available on the association of each NM parameter with the final outcome and whether all 25 parameters should be given equal importance while predicting the outcome in NM patients. We thus aimed to study the association of each NM parameter, total MSS, system-wise MSS and MSI with the final maternal outcome, i.e., NM or death.

Methods

This was a prospective observational study undertaken in a tertiary health care center from July 2015 to Feb 2016. All women with potentially life-threatening conditions (PLTCs) [3] during the study period were identified. Among them, those who fulfilled one or more WHO NM criteria were included. A detailed history of the present pregnancy-related complication(s), adequacy of supervision along with the relevant obstetric and past medical history was obtained. Adequately supervised women were defined as those who had at least one antenatal visit each in first and second trimester and two visits in third trimester. A thorough general physical and systemic examination was done. Patients were then assessed in terms of all 25 WHO NM parameters. Each parameter was given a score of one and MSS was then calculated for every patient on admission by adding all NM parameters present in that particular patient. Using WHO MSI calculator [6], MSI score was given to all patients falling in NM category. After assigning MSS and MSI score to the patients selected for the study, they were then followed up on daily basis with respect to general health condition, laboratory investigations and imaging studies (if done). Based on the final outcome, patients were divided into two groups:

Group A Patients who were NM but improved and were discharged in a stable condition.

Group B Patients who could not survive the complications and died.

The final outcome was then associated with each NM parameter, system-wise MSS, total MSS and MSI.

Statistical analysis

All statistical analysis was done using SPSS software (version 22, SPSS Inc., Chicago, IL, USA). To compare the baseline characteristics of Group A and Group B, mean and standard deviation (SD) was used as descriptive statistics. To test the homogeneity of variance between both the groups, Levene test was used at 5% significance level. Based on Levene test value, it was decided whether to use Independent sample *T* test or Mann–Whitney *U* test for various baseline parameters.

To analyze the association of each WHO NM parameter, system-wise MSS, total MSS and MSI with the final outcome, mean and SD was used as descriptive statistics. Chi-square test was used to analyze the association at 5% significance level. p value ≤ 0.05 was considered statistically significant with 95% confidence interval. The relationship of MSI with total and system-wise MSS was determined using coefficient of determination. We also used the area under the receiver operator characteristics (AUROC) curve to check the validity of MSI model and its capacity in predicting maternal deaths in women with pregnancy-related complications.

Results

4822 patients were admitted to obstetrics department during the study period (including both antenatal and postpartum females). Among them, 1739 (36.1%) patients had PLTCs of which 174 (10%) women fulfilled one or more WHO NM criteria (Table 1). On follow-up, 116 women were discharged under stable condition (Group A) and 58 women

Table 1 Frequency of potentially life-threatening conditions (PLTCs), NM and maternal deaths

Disorders	PLTCs (*N*/%)	Group A (NM) (*N*/%)	Group B (died) (*N*/%)
Hemorrhagic disorder	441 (25.3)	37 (31.9)	14 (24.1)
Infections	44 (2.5)	10 (8.6)	6 (10.3)
Hypertensive disorder	729 (41.9)	21 (18.1)	16 (27.6)
Abortion and ectopic pregnancy	71 (4.1)	4 (3.4)	2 (3.4)
Hepatic disease	210 (12.1)	11 (9.4)	6 (10.3)
Renal disease	23 (1.3)	8 (6.8)	2 (3.4)
Severe anemia	53 (3.0)	13 (11.2)	3 (5.2)
Others	168 (9.7)	12 (10.3)	9 (15.5)
Total	1739	116	58

succumbed to complications (Group B), as shown in Fig. 1. Table 2 depicts the percentage of various WHO NM criteria in entire screened population of 4822 patients and in study population of 174 patients.

Baseline characteristics of study population

The mean age of patients in both the groups was comparable. The percentage of adequately booked and supervised patients in group A and group B was 88.8% and 70.7%, respectively; the difference was found to be statistically significant ($p=0.02$) (Table 3). Among various investigative parameters (done at the time of admission), only prothrombin index (PTI), hemoglobin (Hb), total serum bilirubin (TSB) and aspartate transaminase (AST) were found to be more deranged in patients who died in comparison to NM patients ($p<0.05$).

Comparison of total MSS and MSI in the two groups

The mean total MSS and MSI in group A was 4.41 ± 2.84 and $11.67\pm24.02\%$, respectively. In group B, the mean MSS and MSI were found to be 9.47 ± 3.96 and $58.16\pm36.48\%$, respectively. The maximum and minimum value of total MSS in group A (near miss patients) was 1 and 14, respectively, and in group B (patients who died) was 1 and 16, respectively. The minimum and maximum value of MSI in group A was 0.1% and 92.5%, respectively, and in group B was 0.1% and 95.8%, respectively.

Both these prognostic tools showed statistically significant association with the final outcome ($p<0.001$). Total MSS score also demonstrated significant positive correlation with MSI ($r=0.87$) ($p<0.001$) which indicates that a higher MSS score increases the probability of death in NM patient (Fig. 2).

The MSI also had good accuracy for maternal death prediction in women with markers of organ dysfunction (area under the receiver operator characteristic curve—AUROC 0.838 [95% CI 0.766–0.910]) (Fig. 3).

Association of system-wise MSS with the final outcome

The 25 parameters for WHO near miss criteria can be broadly divided into 6 systemic dysfunctions as discussed below. One patient can have more than single systemic involvement. Hematological dysfunction was the most common system affected among those who survived while respiratory system was the most commonly involved system among those who died.

Cardiovascular system (CVS) dysfunction

All 6 CVS dysfunction markers were significantly associated with the final outcome ($p<0.001$), as shown in Table 4. Shock was the most common parameter found in both the groups followed by the use of vasoactive drugs. On comparing the final outcome in patients with CVS score of 0 (minimum CVS score) and 6 (maximum CVS score), it was seen that 82.75% of patients with CVS score of 0 survived (group A), whereas 100% of patients with CVS score of 6 expired (group B). The mean CVS MSS score in group A

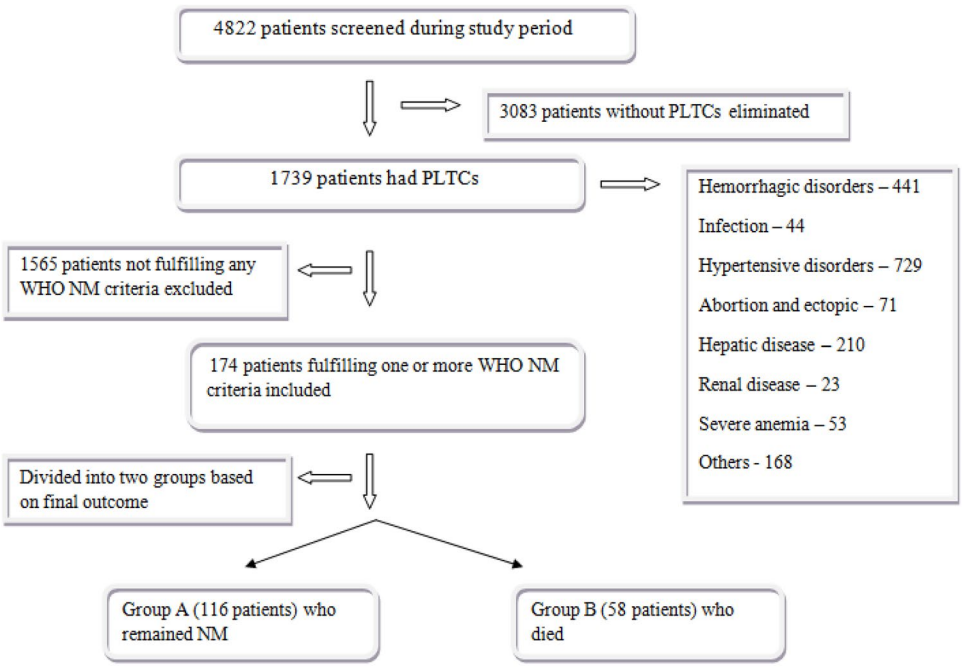

Fig. 1 Flowchart showing stratification of cases

Table 2 Comparison of percentage of various WHO NM criteria in screened population and study population

Symptoms	Number of patients	Percentage (among total screened population—4822 patients)	Percentage (among study population—174 patients)
Cardiovascular parameters			
Shock	77	1.59	40.2
Cardiac arrest	27	0.56	15.5
pH < 7.1	13	0.27	7.5
Lactate > 5	25	0.51	14.4
Vasoactive drugs	64	1.32	36.8
CPR	30	0.62	17.2
Renal parameters			
Oliguria	44	0.91	25.3
Creatinine > 3.5mg/dl	58	1.20	33.3
Dialysis	42	0.87	24.1
Respiratory parameters			
Acute cyanosis	28	0.58	16.1
Gasping	50	1.03	28.7
RR > 40 or < 6 breaths per minute	80	1.65	46
SpO_2 < 90 for ≥ 60 min	81	1.67	46.6
pO_2/FiO_2 < 200 mmHg	33	0.68	19
Intubation	110	2.28	63.2
Neurological parameters			
Coma, LOC > 12 h	35	0.72	20.1
Metabolic coma	3	0.06	1.7
Stroke	0	0	0
Status Epilepticus	2	0.04	1.1
Hematological parameters			
Clotting failure	48	0.99	27.6
Acute thrombocytopenia	67	1.39	38.5
> 5 blood transfusions	51	1.05	29.3
Hepatic parameters			
Jaundice with preeclampsia	14	0.29	8
Bilirubin > 6	41	0.85	23.6
Uterine dysfunction	23	0.47	1.9

was 0.67 ± 1.02 and group B was 2.72 ± 1.95, the difference demonstrated statistical significance ($p < 0.001$). CVS MSS Score was also found to have statistically significant positive correlation with MSI ($r = 0.886$) ($p < 0.001$) (Fig. 4).

Respiratory dysfunction

All 6 respiratory dysfunction parameters had significant association with the final outcome ($p < 0.001$) (Table 4). Of the 21 patients who had a respiratory score of 6, 19 (90.4%) patients could not survive the complication and expired ($p < 0.001$). The average respiratory MSS score in group A was 1.27 ± 1.67 and group B was 3.83 ± 2.01, the difference was statistically significant ($p < 0.001$). Among all systems, respiratory MSS score showed highest positive correlation with MSI ($r = 0.791$) ($p < 0.001$) (Fig. 4).

Renal dysfunction

None of the renal parameters had significant association with the final outcome ($p > 0.05$) (Table 4). On score-wise comparison, it was found that increase in renal score from 0 to 3 did not lead to a significant change in the final outcome. The average renal MSS score in group A was 0.78 ± 1.22 and group B was 0.91 ± 1.31 which was comparable ($p = 0.6$). Renal MSS score also showed positive correlation with MSI ($r = 0.13$), however the correlation was not statistically significant ($p = 0.58$) (Fig. 4).

Neurological dysfunction

Among neurological dysfunction, 2 parameters (coma, loss of consciousness > 12 h and metabolic coma) had significant

Table 3 Baseline characteristics of the two groups

Characteristics	Group A (NM) *N* (%)	Group B (died) *N* (%)	*p* value
Age (in years) mean ± SD)	26.4 ± 5.08	26.19 ± 4.47	0.48
Booking status			
Adequately booked	103 (88.8)	41 (70.7)	0.02
Inadequately booked	2 (1.7)	1 (1.7)	0.42
Unbooked	16 (27.6)	11 (9.5)	0.04
Investigations			
Hemoglobin (g/dl)	8.22 ± 3.05	6.66 ± 2.57	0.014
Platelet count ($\times 10^3$ /mm^3)	128.35 ± 116.69	119.38 ± 109.31	0.69
Total leukocyte count (per microliter)	18,109.48 ± 9757.94	19,782.07 ± 9201.284	0.59
Prothrombin index (%)	83.03 ± 21.79	66.76 ± 24.16	< 0.001
Total serum bilirubin (mg/dl)	3.54 ± 4.71	4.83 ± 4.62	0.006
Aspartate transaminase (U/L)	252.19 ± 634.14	444.29 ± 745.00	0.001
Alanine transaminase (U/L)	186.53 ± 392.97	378.28 ± 613.82	0.448
Alkaline phosphatase (U/L)	244.27 ± 159.99	284.10 ± 206.53	0.48
Urea (mg %)	65.42 ± 59.67	67.69 ± 36.81	0.078
Creatinine (mg %)	2.07 ± 2.33	2.11 ± 1.609	0.14
Sodium (mnol/L)	139.05 ± 6.3	140.9 ± 6.25	0.30
Potassium (mnol/L)	4.64 ± 0.73	4.71 ± 1.16	0.38
Chloride (mnol/L)	104.23 ± 7.72	103.43 ± 7.11	0.10

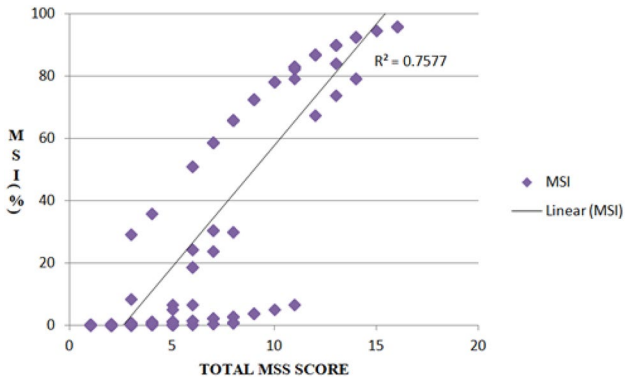

Fig. 2 Correlation of total MSS with MSI

association with the final outcome ($p < 0.05$) (Table 4). The average neurological MSS score in group A and group B was 0.12 ± 0.32 and 0.43 ± 0.53, respectively, which was statistically significant ($p < 0.001$). It was also found that neurological MSS score was significantly correlated with MSI ($r = 0.352$) ($p < 0.001$) (Fig. 4).

Hematological dysfunction

Although acute thrombocytopenia (< 50,000 platelet count) was the most common hematological manifestation in both the study groups, its association with the final outcome was not statistically significant ($p = 0.86$). The other two parameters (clotting failure and more than five blood transfusions) depicted a statistically significant association with the final outcome (Table 4). The average hematological MSS score in NM patients was 0.95 ± 0.75 and in those who expired was 0.95 ± 0.92 which was comparable in both groups ($p = 0.78$). No correlation was noted between hematological MSS and MSI ($r = 0.012$) (Fig. 4).

Hepatic dysfunction

Only bilirubin > 6 mg/dl showed statistically significant association with the final outcome ($p < 0.05$) (Table 4). Majority of patients with bilirubin > 6 mg/dl were found to be either hepatitis E virus (HEV) positive or were diagnosed as acute fatty liver of pregnancy (AFLP). 73% of patients with HEV positivity were NM, whereas 78.6% of patients diagnosed as AFLP expired despite being delivered within 12 h of diagnosis. Hepatic system did not depict a statistically significant correlation with MSI ($r = -0.054$) (Fig. 4).

Uterine dysfunction

Hysterectomy (due to infection or hemorrhage) was performed in 17 (14.6%) patients in group A and 6 (10.3%) patients in group B. Hysterectomy was found to be negatively correlated with MSI ($r = -0.07$) as it was a life -aving intervention done in case of excessive hemorrhage

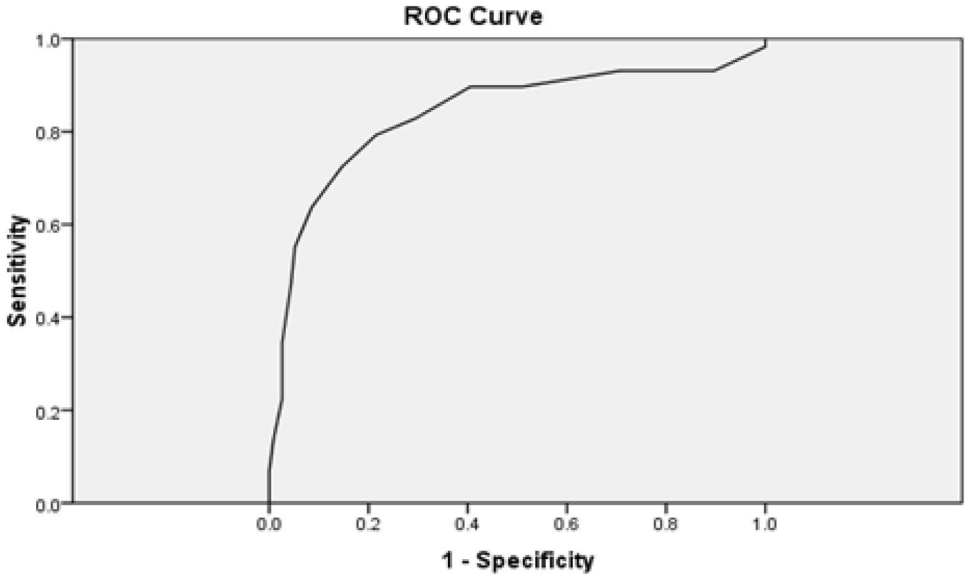

Fig. 3 Receiver operating characteristic (ROC) curve of MSI

or infection. However, this correlation did not demonstrate statistical significance ($p = 0.354$).

Discussion and conclusion

The introduction of maternal NM has changed the concept of maternal care and has shifted the focus from maternal deaths to early identification of life-threatening conditions and their appropriate management to achieve a favorable outcome. WHO NM parameters cover almost all possible organ systems which can be affected secondary to any pregnancy-related complications. However, not all 25 criteria have equal and significant predictive value to determine the final outcome. There is paucity of literature regarding association of each WHO NM criteria with the final outcome.

In the present study, the most common criteria found in NM patients was intubation not related to anesthesia (45.7%) followed by massive blood transfusion of more than 5 packed red blood cell (PRBC) (37.9%) and acute thrombocytopenia (35.3%), respectively. 17 of the 25 WHO NM criteria were found to be significantly associated with the final outcome. The criteria which did not have a significant association with the final outcome were all the renal parameters (decreased urine output, creatinine > 3.5 mg/dl and dialysis), status epilepticus, acute thrombocytopenia, jaundice in the presence of preeclampsia and hysterectomy. None of the patients in either group presented to us with stroke, hence its association with the final outcome could not be determined. Although acute thrombocytopenia was the third most common criteria in NM patients, the difference in the number of patients fulfilling this criterion between those who died and those who survived was not significant enough to affect the final outcome. Hence, it is not imperative that the most prevalent WHO criterion is also a reliable predictor of final outcome as shown in our study.

In a WHO multicountry survey (WHOMCS), the WHO maternal NM criteria were found to be accurate and highly associated with maternal deaths [7]. In patients who became NM, transfusion of more than 5 PRBC was the most common criteria noted followed by shock and acute thrombocytopenia. Although all 25 NM criteria analyzed as a whole were significantly associated with maternal deaths, the survey did not analyze the association of each NM parameter individually with the final outcome.

In another study from Uganda, the commonest NM criteria used to diagnose severe maternal outcomes were shock, respiratory rate of > 40 per minute and acute thrombocytopenia [8]. Shock, prolonged comatosed state (for up to 12 h), intubation unrelated to anesthesia, and cardiopulmonary resuscitation were the NM criteria that were predictive of a maternal death. Litorp et al. found that the most common criteria fulfilled by women experiencing maternal NM events were fits (35%), shock (24%), and hysterectomy (10%) [9]. In another study from Malaysia, transfusion of 5 or more units of PRBC (61.7%), hysterectomy (40.4%), lactate > 5 mmol/L (21.3%) and shock (8.5%) were the most common WHO criteria found in NM patients [10]. However, both these studies have not evaluated the prognostic value of these NM criteria in predicting death.

In our study, hematological/coagulation (72.4%) followed by respiratory (50%) and hepatic (41.4%) dysfunction were the three most frequent organ dysfunctions seen in NM patients. Although the hematological system was among the most common systems involved in both the groups, its involvement did not have a significant impact on the final outcome. Souza et al. from their study concluded that CVS (49.4%), respiratory (30.4%) and coagulation (27.5%)

Table 4 Comparison of organ dysfunction parameters in the two groups

Characters	Total (*n*)	Group A (NM) (yes/no) (%)	Group B (died) (yes/no) (%)	*p* value
Cardiovascular parameters				
Shock	77 (40.2)	37/79 (31.9/68.1)	40/18 (68.96/31.04)	< 0.001
Cardiac arrest	27 (15.5)	2/114 (1.7/98.3)	25/33 (43.1/56.9)	< 0.001
pH < 7.1	13 (7.5)	3/113 (2.6/97.4)	10/48 (17.2/82.8)	0.001
Lactate > 5	25 (14.4)	7/109 (6.03/93.97)	18/40 (31.03/68.97)	< 0.001
Vasoactive drugs	64 (36.8)	24/92 (20.7/79.3)	40/18 (68.96/31.04)	< 0.001
CPR	30 (17.2)	5/111 (4.3/95.7)	25/33 (43.1/56.9)	< 0.001
Renal parameters				
Oliguria	44 (25.3)	26/90 (22.4/77.6)	18/40 (31.03/68.97)	0.217
Creatinine > 3.5mg/dl	58 (33.3)	39/77 (33.6/66.4)	19/39 (32.7/67.3)	0.909
Dialysis	42 (24.1)	26/90 (22.4/77.6)	16/42 (27.6/72.4)	0.452
Respiratory parameters				
Acute cyanosis	28 (16.1)	6/110 (5.2/94.8)	22/36 (37.9/62.1)	< 0.001
Gasping	50 (28.7)	16/100 (13.8/86.2)	34/24 (58.6/41.4)	< 0.001
RR > 40 or < 6 breaths per minute	80 (46)	30/86 (25.9/74.1)	50/8 (86.2/13.8)	< 0.001
SpO_2 < 90 for ≥ 60 min	81 (46.6)	36/80 (31.03/68.97)	45/13 (77.6/22.4)	< 0.001
pO_2/FiO_2 < 200 mmHg	33 (19)	8/108 (6.9/93.1)	25/33 (43.1/56.9)	< 0.001
Intubation	110 (63.2)	53/63 (45.7/54.3)	57/1 (98.3/1.7)	< 0.001
Neurological parameters				
Coma, LOC > 12 h	35 (20.1)	13/103 (11.2/88.8)	22/36 (37.9/62.1)	< 0.001
Metabolic coma	3 (1.7)	0/116 (0/100)	3/55 (5.2/94.8)	0.013
Stroke	0 (0)	0/116 (0/100)	0/58 (0/100)	
Status Epilepticus	2 (1.1)	2/114 (1.7/98.3)	0/58 (0/100)	0.315
Hematological parameters				
Clotting failure	48 (27.6)	25/91 (21.5/78.5)	23/35 (39.7/60.3)	0.012
Acute thrombocytopenia	67 (38.5)	44/72 (37.9/62.1)	23/35 (39.7/60.3)	0.826
> 5 blood transfusions	51 (29.3)	41/75 (35.3/64.7)	10/48 (17.2/82.8)	0.013
Hepatic parameters				
Jaundice with preeclampsia	14 (8)	7/109 (6.03/93.97)	7/51 (12.1/87.9)	0.308
Bilirubin > 6	41 (23.6)	26/90 (22.4/77.6)	15/43 (25.9/74.1)	0.013
Uterine dysfunction	23 (1.9)	17/99 (14.6/85.4)	6/52 (10.3/89.7)	0.425

disorders were the most frequent organ dysfunctions found in mothers with severe maternal outcome (NM and maternal deaths), similar to the observations of our study [7]. In another study, it was observed that CVS, respiratory and coagulation disorders are the most common organ dysfunctions involved in NM patients [11].

In the current study, the organ dysfunctions which were found to be significantly associated with the final outcome and showed positive correlation with MSI were—CVS, respiratory and neurological dysfunctions. So, patients involving these three systems probably require more meticulous and vigilant care with immediate life-saving interventions to prevent them from dying as compared to patients with renal, hematological and hepatic involvement. This observation highlights that all systems should not be given equal weightage while calculating MSS for a patient as a marker for prognostication.

A study analyzed the validity of the WHO organ dysfunction-based criteria for identification of maternal NM and concluded that dysfunction or failure of CVS and respiratory system as reflected by the use of vasoactive drugs and need for ventilator support are directly associated with a worse prognosis and higher mortality rate, similar to the findings noted in our study [12]. Another study from Nigeria concluded that the mortality indices were poor for all organ dysfunctions in general, but were worse for renal and respiratory dysfunctions [11]. Similarly, one more study from Iraq also reported highest mortality index (40%) for renal dysfunction [13]. This was different from our observation where renal dysfunction was not associated with higher mortality index.

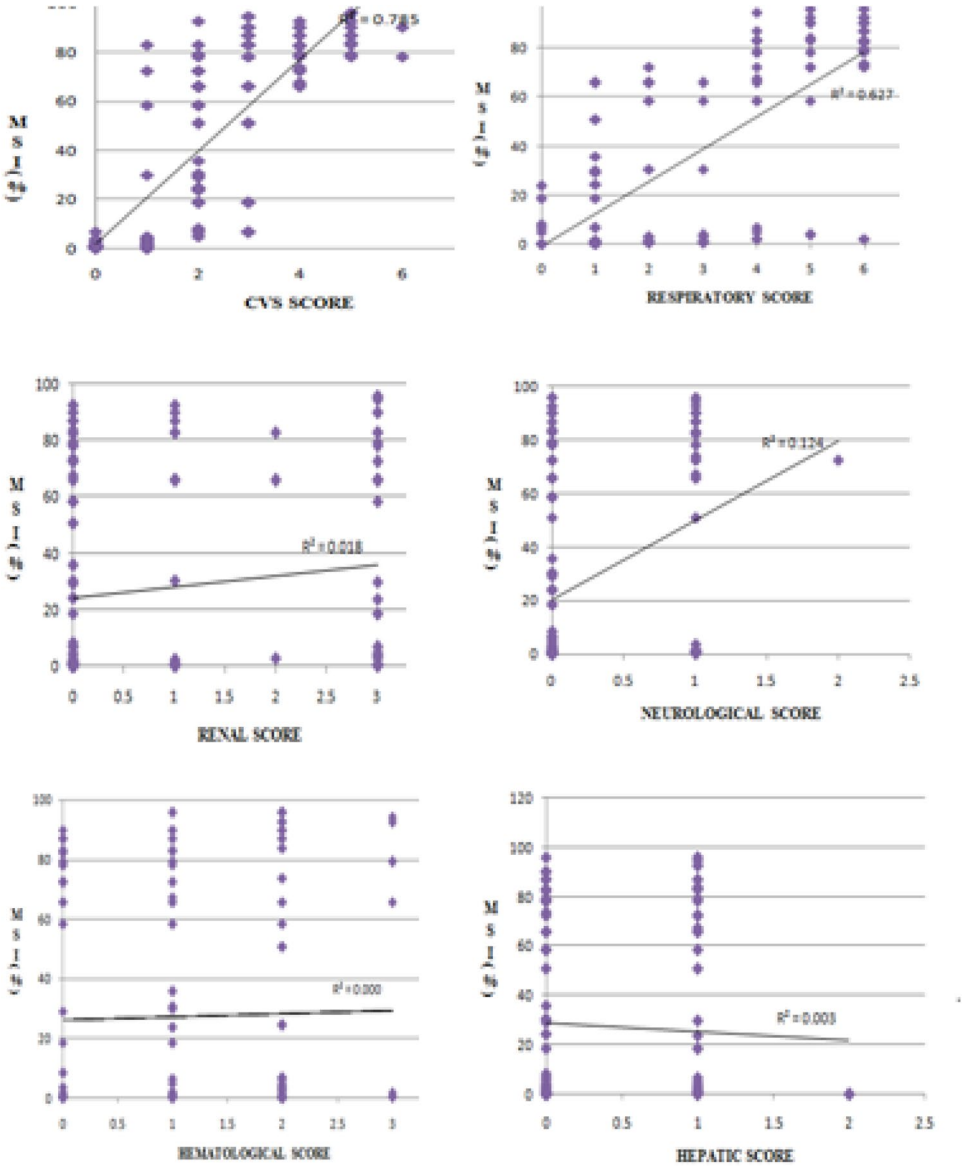

Fig. 4 Correlation of individual system-wise MSS with MSI

The possible explanation for this difference might be that the most common cause of renal dysfunction in our patients was preeclampsia induced acute kidney injury which improved drastically after termination of pregnancy. Highly advanced dialysis unit at our center can be another reason for lower mortality index of renal system (10.9%) in our study.

MSS and MSI are two scoring systems devised to assess the severity of maternal complications and predict the risk of mortality in a NM patient, respectively. In our study, the average MSS of patients who died was more than twice the average MSS of those who were NM (4.41 vs. 9.47). Similarly, the average MSI of patients who died was approximately five times the average MSI of patients who survived the complications (11.67% vs. 58.16%). A large multicenter cross-sectional study conducted to validate the WHO NM criteria and MSI model concluded that MSS and MSI model contribute for a better assessment of severity of obstetric patients and enables a benchmark approach to quality of care of women [7]. Another study done to assess the quality of care of women with severe maternal morbidity yielded similar results concluding that MSI was a useful tool for identifying differences in maternal mortality ratios which may contribute to the analysis of obstetric health systems and identification of weaknesses [14]. WHOMCS also concluded that the MSI had good accuracy for maternal death prediction in women with markers of organ dysfunction (AUROC 0.826 [95% CI 0.802–0.851]) and can be used to monitor and assess the performance of health facilities providing care to women with complications related to pregnancy [7].

It is important to highlight that our study primarily represents the association of various organ dysfunctions with the outcome. However, it is equally critical to understand

that the same underlying pathology can affect one or more organ systems with varying degrees of severity depending upon the infrastructure and expertise available at the time of management. A patient with antepartum or postpartum hemorrhage can have different MSS and MSI based on the level of care provided. This calls for a uniform and strict protocol-based treatment to be followed at all health care centers, especially in developing countries, with referral at appropriate time so that a patient presenting as NM can be discharged in stable condition.

Our study was limited by its duration and sample size. Data collection over a few years will provide a better and more comprehensive information about the maternal health status.

To conclude, NM is a new paradigm in the concept of maternal health care, diverting our attention from maternal deaths to those surviving severe pregnancy-related life-threatening conditions. The MSS and MSI act as good prognostic tools to assess the severity of maternal complications and estimate the probability of death in patients presenting as NM. However, all system dysfunctions do not contribute equally in predicting the severity of maternal morbidity. Hence, rather than giving one score for each NM parameter, different scores per NM parameter and system should be assigned while calculating MSS for a NM patient to obtain a more realistic outlook of maternal health status.

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Author contributions All authors contributed significantly to manuscript preparation. RP was involved in study setup, study design, data review and analysis, data management and drafting of manuscript. VJ conceived the study, participated in study design, data management and manuscript editing. RB and PS performed data review and edited the manuscript. KJ contributed in data analysis and manuscript editing.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflicts of interest.

Ethics approval The study was reviewed and approved by the institute's ethics committee, PGIMER, Chandigarh, on 11/9/2015 (Reference Number- NK/2210/MD/9907–08).

Informed consent An informed written consent was obtained from patients/relatives after fully explaining the nature and purpose of study.

Research on animals or humans This study did not involve any research conducted on animals. An informed written consent was obtained from patients/relatives after fully explaining the nature and purpose of study.

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