ORIGINAL ARTICLE

Obstetric Early Warning Score for Prognostication of Critically Ill Obstetric Patient

Monali Khergade[1], Jyotsna Suri[2], Rekha Bharti[3], Divya Pandey[4], Sumitra Bachani[5], Pratima Mittal[6]

Abstract

Introduction: Obstetric early warning score (OEWS) has been used conventionally for early identification of deteriorating obstetric patients in the labor room and ward settings. This study was conducted to determine if this simple clinical score could be used for prognosticating a critically ill patient in the ICU setting instead of sequential organ failure assessment score (SOFA) and acute physiology and chronic health evaluation (APACHE II) score.

Materials and Methods: A cohort study was conducted at Obstetrics Critical Care Unit, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi. A total of 250 obstetric patients were recruited after informed consent. The OEWS, SOFA, and APACHE II scores were calculated within 24 hours of admission. The patients were followed to study the maternal outcome.

Results: The area under receiver operator characteristic (AUROC) curve of OEWS, SOFA, and APACHE II for prediction of maternal mortality was 0.894 (95% CI, 0.849–0.929), 0.924 (95% CI, 0.884–0.954), and 0.93 (95% CI, 0.891–0.958), respectively. The standardized mortality ratio (SMR) for OEWS, SOFA, and APACHE II was 66.3, 62.5, and 69.15%, respectively.

Conclusion: Obstetric early warning score is as effective as the conventional SOFA and APACHE II to prognosticate the obstetric patient. Since OEWS is based only on clinical criteria, it can be done immediately on admission and can help in early allocation of appropriate manpower and resources for optimum outcome.

Clinical significance: The clinical application of this study will help intensivists to prognosticate the critically ill obstetric patients immediately following admission to the critical care unit.

Keywords: Acute physiology and chronic health evaluation score, Critical care obstetrics, Maternal mortality, Obstetric early warning score, Prognostic scoring models, Sequential organ failure assessment score.

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Introduction

Childbirth is a major life event for women and their families. However, some women become critically ill during this time and it becomes important to provide critical care services to such patients who are young, otherwise healthy, and cornerstones of their families and society at large. It is estimated that about 830 women die each day worldwide from preventable causes related to pregnancy and childbirth with the majority of such deaths occurring in developing countries.[1] Critical care is required in about 2% of pregnant women; however, when required there is a high maternal mortality ranging from 3.4 to 14%.[2–4] The indications for admission to the critical care unit may be direct obstetric causes like preeclampsia-eclampsia, obstetric hemorrhage, and puerperal sepsis as well as indirect causes like heart disease and liver disorders.[5]

Predictive models are extremely important tools for prognosticating a critically ill patient in the ICU setting, which help not only in immediate allocation of resources but also in counseling of the relatives of the patient. Further improving or deteriorating scores on a daily basis can help in guiding the treatment of the patient. Prognostic scoring systems used in nonpregnant population are either based on organ dysfunction, such as sequential organ failure assessment (SOFA) score, multiple organ dysfunction score (MODS), logistic organ dysfunction score (LODS), or on acute physiology chronic health parameters such as acute physiology and chronic health evaluation (APACHE II) score.[6–9] Some others are based on physiological variables and age such as simplified acute physiological score (SAPS I-III).[10]

[1–6]Department of Obstetrics and Gynecology, Vardhaman Mahavir Medical College and Safdarjung Hospital, New Delhi, India

Corresponding Author: Jyotsna Suri, Department of Obstetrics and Gynecology, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India, Phone: +91 9810858358, e-mail: jyotsnasuri@gmail.com

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Pregnancy is associated with many physiological changes involving cardiovascular, respiratory, renal, and hematological system; thus, interpretation of these scores is more challenging in obstetric population. It has been seen that the use of these scores in obstetric patients often overpredicts mortality.[11,12] Overestimation of mortality risk by these scores in obstetric patients likely relates to pregnancy physiological changes that are not included in mortality scores, demographic characteristics, and lack of comorbidities in this population, and the significant and unique improvement in mortality that follows specific interventions in pregnancy. The standardized mortality ratio (SMR) is a ratio between observed number of deaths and number of deaths predicted by the score. It has been observed that the SMR of most of the prognostic scores used in obstetric population grossly overpredicts the maternal mortality.[9,11,13–16]

However, since the concept of obstetric critical care is relatively new, there are no validated scoring systems for exclusive use in the critically ill obstetric patients. An obstetric specific statistically derived score is the Carle's obstetric early warning score (OEWS), which was originally developed for triaging the obstetric patients in the labor wards; however, this has been recently described as a prognostic score in the ICU setting also with some modifications.[17,18] The major advantage of this score is that it uses the triggers according to the physiological changes of pregnant women and secondly does not require any laboratory value, as it is based on clinical parameters; hence, it is simple to calculate and less time-consuming. As there is only scant retrospective data and none from the Indian subcontinent, this study was conducted with the aim of prospectively comparing the OEWS with SOFA and APACHE II for prediction of mortality in a dedicated obstetric critical care unit (OCCU) of a tertiary care referral hospital.

Materials and Methods

Study Design

Prospective cohort.

Setting

Department of Obstetrics and Gynecology, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, a tertiary care referral teaching institute that conducts about 28,000 deliveries annually. The facility has a dedicated 15-bedded OCCU managed by obstetricians and supported by Department of Anesthesiology and Department of Pulmonary and Critical Care Medicine.

Study Population

A total of 250 obstetric patients (pregnant and postpartum women within 42 days of delivery) admitted in the dedicated OCCU were recruited. An informed consent was taken from them or from their legal representative if they were too sick to do so.

Subject Evaluation

All the three scores—Carle's OEWS, SOFA, and APACHE II—were calculated within 24 hours of OCCU admission. The parameters with their numerical values used for calculation of OEWS are shown in Figure 1.

The blood pressure was recorded with noninvasive monitors (Edan elite v6). The cuff was tied on the right arm with the patient in the left lateral recumbent position. The respiratory rate (RR) and heart rate (HR) were also noted from the monitor after placing chest leads. Temperature was recorded from the axillary area with a temperature probe. A slight modification was made while noting the temperature, since we noted the axillary temperature and not the rectal temperature as defined for the APACHE II score. All lab parameters were obtained through venous blood sampling. Partial pressure of oxygen (PaO_2) in arterial blood (in mm Hg) was recorded from the arterial blood gas (ABG) analysis. The fraction of inspired oxygen (FiO_2) was noted directly from the ventilator in ventilated patients. For those who were on oxygen therapy, the FiO_2 was determined by the rate of oxygen flow (L/minute).

The patients were under continuous vital monitoring and the readings of vital parameters were noted from monitor records. For calculation of score, the most abnormal reading of each clinical and lab parameter over the first 24 hours of admission was considered. The patients were followed to study the maternal and fetal outcomes. The primary outcome was maternal death, which was defined as death during pregnancy or within 42 days postpartum whereas the secondary outcome was the length of ICU stay, the number of hours of ventilation and vasopressor requirement, and the number of dialysis required.[19]

Clinical Intensive Care National Audit and Research Center Obstetric Early Warning Score

	3	2	1	Normal[a]	1	2	3
Systolic blood pressure, mm Hg[b]	<80	80–89		90–139	140–149	150–159	160
Diastolic blood pressure, mm Hg				<90	90–99	100–109	110
Respiratory rate/min	<10			10–17	18–24	25–29	30
Heart rate/min	<60			60–110		111–149	150
$\%O_2$ required to maintain SpO_2 96%[c]				Room air	24–39%		40%
Temperature, °C	<34.0		34.0–35.0	35.1–37.9	38.0–38.9		39
Conscience level				Alert			Not alert

Fig. 1: Carle's obstetric early warning score[17]

Statistical Analysis

Results were tabulated and subjected to the statistical analysis using the Statistical Package for Social Sciences (SPSS) version 21.0. Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± standard deviation. The receiver operating characteristic curve was used to find out area under curve of various scores for predicting mortality. The diagnostic test was used to calculate sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV). A *p* value of <0.05 was considered statistically significant.

Results

It was observed that indications directly related to complications of pregnancy represented the most frequent causes of OCCU admission such as hemorrhagic conditions (20%), followed by sepsis (18.8%) (puerperal sepsis 16%, septic abortions 2.8%), and hypertensive disorders (15.6%). It is noteworthy that anemia contributed to as many as 17.6% of the OCCU admissions (Table 1). The mean age of the patients was 25.07 ± 3.94 years. The mean SOFA score was 5.56 ± 4.42, whereas the mean APACHE II and OEWS were 11.14 ± 7.16 and 8.2 ± 5.22, respectively (Table 2). For the women who had mortality, the mean SOFA score was 10.69 ± 3.57, mean APACHE II was 19.37 ± 5.23, and mean OEWS was 13.57 ± 2.93. We observed a maternal mortality rate of 26% (65 out of 250). Sepsis contributed for maximum number of maternal deaths (23%), followed by acute kidney injury and eclampsia (Table 3).

Table 1: Indications for admission to obstetric critical care unit (OCCU)

Indications for admission to OCCU		*Frequency (n = 250)*	*Percentage*
Hemorrhage	First-trimester bleeding including ruptured ectopic, abortions	18	7.20
	Antepartum hemorrhage	16	6.40
	Postpartum hemorrhage	16	6.40
Severe anemia		44	17.6
Sepsis	Septic abortion	7	2.80
	Puerperal sepsis	40	16.00
	Unrelated to pregnancy	2	0.80
Chronic hypertension/ severe preeclampsia/ eclampsia		39	15.60
Medical disorders	Heart disease	11	4.40
	Tuberculosis	1	0.40
	Febrile illness	18	7.20
	Epilepsy	13	5.20
	Gastroenteritis	4	1.60
Organ failure	Acute kidney injury	29	11.60
	Adult respiratory distress syndrome	6	2.40
	Liver failure	12	4.80
	Encephalopathy	2	0.80

The AUROC of OEWS was 0.894 (95% CI, 0.849–0.929) with *p* value <0.0001; cutoff of >9 had a sensitivity (Sn) of 90.77% and specificity (Sp) of 78.92% with PPV 60.2% and NPV 96.1%; AUROC of APACHE II was 0.93 (95% CI, 0.891–0.958) with *p* value <0.0001; cutoff of >12 had a Sn of 93.85% and Sp of 82.16% with PPV 64.9% and NPV 97.4%, whereas the AUROC of SOFA score was 0.924 (95% CI, 0.884–0.954) with *p* value <0.0001; cutoff of >5 had a Sn of 92.31% and Sp of 76.22% with PPV 57.7% and NPV 96.6% (Fig. 2 and Table 4).

The standard mortality rate (SMR) of OEWS was 66.66%, which was comparable to that of APACHE II and SOFA, indicating that all the three scores were overpredicting maternal mortality (Table 5).

Unlike APACHE II and SOFA score, the OEWS was found to correlate significantly with the length of ICU stay and the number of hours on ventilation, which were the secondary outcomes in the study (Table 6).

Discussion

The most common indications for admission to the obstetric CCU in this study were direct obstetric conditions like hemorrhage, sepsis, and preeclampsia. Sepsis contributed for maximum number of maternal deaths (23%), whereas hemorrhage was responsible for only around 8% of the deaths though being the commonest indication for admission to the critical care unit as seen in Tables 1 and 3, probably reflecting that aggressive management of postpartum hemorrhage (PPH) can save lives whereas sepsis especially after development of multiorgan dysfunction is the most challenging condition. It is noteworthy that most of the cases of puerperal sepsis had an unsupervised delivery and reported after the golden first hour, again reiterating the importance of institutional deliveries in our country, which is perceived as one of the most important intervention for decreasing maternal mortality.[20]

We observed that all the three scores, OEWS, SOFA, and APACHE II, had a comparable predictive value for maternal mortality, which was statistically significant.

Although APACHE II and SOFA score were found to be useful as maternal mortality predictors, they needed to be calculated on the basis of lab parameters, some of which were available only after 6–8 hours. During the course of the study, we found that calculating the OEW score was very simple, less time-consuming, and did not require any lab report or any lengthy calculation. It was very user-friendly and we were able to prognosticate the patient immediately on admission. With a cut-off threshold of >9, it had a sensitivity of 90.7% and a specificity of 78.9% in predicting maternal mortality. Further, OEWS was found to significantly correlate with length of ICU stay ($p = 0.029$, $R = 0.138$) and number of hours on ventilation ($p = 0.025$, $R = 0.228$). However, APACHE II and SOFA score were not found to correlate with the length of CCU stay and number of hours of ventilation.

In a retrospective cohort study performed by Paternina-Caicedo et al. from January 2006 through December 2011 in Colombia, 702 pregnant or postpartum women who were admitted consecutively to the ICU were studied to determine the role of OEWS for prediction of maternal mortality. The AUROC of the OEWS in discrimination of maternal death was 0.84 (95% CI, 0.75–0.92). Peripartum women with normal values of obstetric early warning score had 0% mortality rate, while those with high obstetric early warning score values (>6) had a mortality rate of 6.3%. The overall predictive value of the obstetric early warning score was better when the main cause of admission was directly related to pregnancy or the postpartum state. However, the biggest limitation of this study was that it was

Table 2: Clinical characteristics and laboratory parameters of the patients

	Mean	*Median*	*Min–Max*	*Interquartile range*
Age (years)	25.07 ± 3.94	24	19–42	22–26
Heart rate	110.84 ± 19.39	111	34–180	102–122
Respiratory rate	22.99 ± 7.77	22	6–52	17–28
Temperature in °C	38.24 ± 1.32	38	37–42	37–39
Systolic blood pressure	102.37 ± 30.2	98	50–200	78–120
Diastolic blood pressure	65.19 ± 21.98	60	26–120	50–77
Mean arterial pressure	77.57 ± 24.11	73.5	40–146.67	60–87
% O_2 required to maintain SpO_2 96%	36.32 ± 22.6	20	20–100	20–40
Fraction of inspired oxygen (FiO_2)	0.36 ± 0.22	0.2	0.1–1	0.200–0.400
PaO_2	93.22 ± 24.9	89	40.3–248	79–99
PaO_2/FiO_2	344.25 ± 166.48	402.5	43–900	190–485
Arterial pH	7.34 ± 0.14	7.34	7–7.67	7.230–7.440
Serum sodium (mEq/L)	139.64 ± 9.71	141.5	120–170	133–145
Serum potassium (mEq/L)	4.28 ± 1	4.2	2.5–7	3.400–5
Serum creatinine (mg/dL)	1.53 ± 1.35	1.1	0.12–8.8	0.800–1.700
Serum bilirubin (mg/dL)	1.72 ± 1.86	1.2	0.2–15	0.800–1.800
Hematocrit (%)	26.25 ± 6.82	28	12–42	20–31
WBC (cells/uL)	16,377.09 ± 6028.35	15950	1300–40,000	13,400–18,900
Platelet count (u/L)	220,680 ± 129,262.7	200,000	7000–600,000	100,000–300,000
Glasgow coma scale (GCS)	13.04 ± 2.93	15	3–15	11–15
SOFA score	5.56 ± 4.42	5	0–20	2–9
OEW score	8.2 ± 5.22	8	0–20	3–13
APACHE II score	11.14 ± 7.16	10	0–34	5–16
Length of stay in ICU in days	5.67 ± 6.27	4	0.5–50	3–6
Number of hours on ventilation	48.43 ± 50.58	40	1–350	20–58
Number of hours on vasopressor infusion	35.08 ± 27.4	32	2–104	16.500–40
Number of dialysis required	4.15 ± 1.54	4	2–8	3–5

Table 3: Major etiology contributing to maternal mortality

Cause of death		*Frequency (n = 65)*	*Percentage*
Sepsis		15	23
Acute kidney injury		12	18.4
Eclampsia/severe preeclampsia		12	18.4
Anemia		11	16.92
Febrile illness		3	4.6
Heart disease		3	4.6
Hepatic failure		3	4.6
Antepartum hemorrhage	Abruption	3	4
	Placenta previa	1	1.5
Postpartum hemorrhage		2	3
Total		65	100

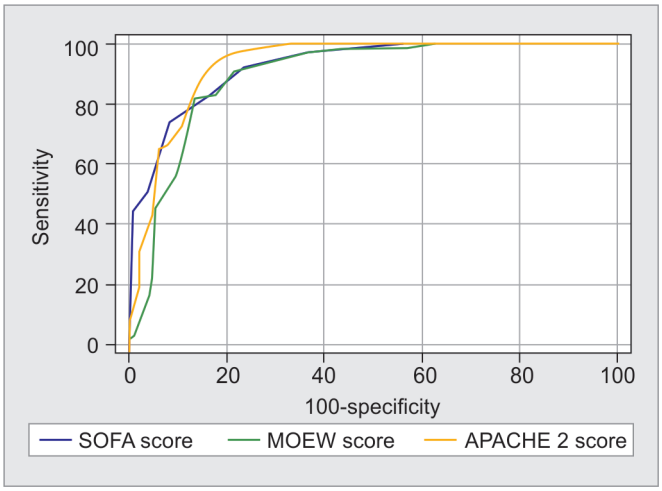

Fig. 2: Area-under-receiver operator characteristic of sequential organ failure assessment score, obstetric early warning score, and acute physiology and chronic health evaluation scores for prediction of maternal mortality

retrospective in nature with resultant information bias. Moreover, they did not compare the performance of OEWS with the more intensively studied SOFA and APCHE II scores.[18]

Another interesting fact that we found during the analysis of the data was that whereas the NPV of APACHE II, SOFA, and OEWS was very good at 97.4, 96.6, and 96.1%, respectively, the PPVs of all the three scores were quite low at 64.9, 57.7, and 60.2%, respectively. The SMR for OEWS, SOFA, and APACHE II was 66.3, 62.5, and 69.15%, respectively. Hence, it can be seen that all the scores tend to overpredict the maternal mortalities, which has also been observed by others.[9,11,13–16] Thus, the OEWS, which is an obstetric specific score, did not fare better than other general scores in overprediction of outcomes. In another study Aarvold et al. compared four general scores with an obstetric specific score, "sepsis in obstetrics score" (SOS), which was originally developed for emergency settings but

Table 4: Area-under-receiver operator characteristic curve, sensitivity, specificity, positive predictive value and negative predictive value of APACHE II, OEWS, and SOFA scores for prediction of maternal mortality

Scores	*AUROC*	*p value*	*Cutoff*	*Sensitivity*	*Specificity*	*Positive predictive value*	*Negative predictive value*
APACHE II	0.93 (95% CI-0.891 to 0.958)	<0.0001	>12	93.85 (95% CI = 85–98.3)	82.16 (95% CI = 75.9–87.4)	64.9 (95% CI = 54.4–74.5)	97.4 (95% CI = 93.6–99.3)
OEWS	0.894 (95% CI = 0.849–0.929)	<0.0001	>9	90.77 (95% CI = 81–96.5)	78.92 (95% CI = 72.3–84.6)	60.2 (95% CI = 49.8–70)	96.1 (95% CI = 91.6–98.5)
SOFA	0.924 (95% CI = 0.884–0.954)	<0.0001	>5	92.31 (95% CI = 83–97.5)	76.22 (96% CI = 69.4–82.2)	57.7 (95% CI = 47.6–67.5)	96.6 (95% CI = 92.2–98.9)

Table 5: Standardized mortality ratio of APACHE II, OEWS, and SOFA scores

Score	*Observer maternal mortality (%)*	*Predicted maternal mortality (%)*	*Standardized mortality ratio (%)*
APACHE II score	26.00	37.60	69.15
OEWS score	26.00	39.20	66.33
SOFA score	26.00	41.60	62.50

Table 6: Correlation of APACHE II, OEW, and SOFA scores with secondary maternal outcomes

Secondary outcome		*APACHE II score*	*OEW score*	*SOFA score*
Length of stay in ICU in days	Correlation coefficient	0.095	0.138	0.093
	p value	0.1353	0.0297	0.144
	n	250	250	250
Number of dialysis required	Correlation coefficient	−0.231	0.017	0.002
	p value	0.2557	0.9333	0.9911
	n	26	26	26
Number of hours on vasopressor infusion	Correlation coefficient	0.136	0.069	−0.003
	p value	0.2866	0.5925	0.979
	n	63	63	63
Number of hours on ventilation	Correlation coefficient	0.178	0.228	0.08
	p value	0.0821	0.0255	0.4357
	n	96	96	96

was modified by the authors for use in the ICU. They found that the obstetric specific score was not superior to the other general scores. The SOS, APACHE II, SAPS II, SOFA, and MODS scores gave AUROC curves of 0.67, 0.68, 0.72, 0.79, and 0.84 for prediction of mortality in the obstetric cohort, respectively. They concluded that the MODS is a simple organ-based score and performs well as a predictor in ICU even in the obstetric sepsis patients over the obstetric specific score.[21]

This study was primarily conducted to find a simple and accurate prognostic model, which could be used in the critically ill obstetric patients. We have been using the SOFA score but faced two major problems with it. First, we had to wait for the lab reports to determine the score, hence wasting precious time; and second, it overpredicted maternal mortality. The first problem can be overcome by using the OEWS; however, a more representative score for obstetric patients with a good SMR still evades us.

The strength of this study lies in that it was prospective in nature with a robust sample size and has been conducted in a dedicated OCCU. The main limitation was that these scores could not be assessed in nonpregnant, age-, and sex-matched controls as the number of nonpregnant young women in the general ICU was found to be very low.

Conclusion

Hence, it can be concluded from this study that Carle's OEWS can stratify risk and predict mortality in critically ill obstetric patients as effectively as SOFA and APACHE II. Major advantage of OEWS is that it does not need any laboratory parameter and hence calculation is easy and less time-consuming. Thus, it can be done immediately on admission of patient and can help in early allocation of the appropriate manpower and other resources for optimum outcome. However, it was not found to be superior to other scores from the point of view of overprediction of maternal mortality in spite of its pregnancy-specific triggers.

Clinical Significance

The clinical application of this study will help intensivists to prognosticate the critically ill obstetric patients immediately following admission to the critical care unit, which will help in optimizing the management.

To reduce maternal mortality, timely recognition and treatment of severe obstetric complications is crucial and provision of critical care is the need of hour. Obstetric critical care is an emerging topic and challenging too. Further research is warranted in developing prognostic scores for use in obstetric ICUs, which consider the physiological changes of pregnancy and do not overpredict maternal mortality.

References

1. Alkema L, Chou D, Hogan D, Zhang S, Moller AB, Gemmill A, et al. Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN maternal mortality estimation inter-agency group. The Lancet 2016;387(10017):462–474. DOI: 10.1016/S0140-6736(15)00838-7.
2. Wanderer JP, Leffert LR, Mhyre JM, Kuklina EV, Callaghan WM, Bateman BT. Epidemiology of obstetric-related ICU admissions in Maryland: 1999-2008. Crit Care Med 2013;41(8):1844. DOI: 10.1097/CCM.0b013e31828a3e24.
3. Callaghan WM. Overview of maternal mortality in the United States. Semin Perinatol 2012;36(1):2. DOI: 10.1053/j.semperi.2011.09.002.
4. Vasquez DN, Das Neves AV, Vidal L, Moseinco M, Lapadula J, Zakalik G, et al. Characteristics, outcomes, and predictability of critically ill obstetric patients: a multicenter prospective cohort study. Crit Care Med 2015;43(9):1887. DOI: 10.1097/CCM.0000000000001139.

5. Pollock W, Rose L, Dennis CL. Pregnant and postpartum admissions to the intensive care unit: a systematic review. Intensive Care Med 2010;36(9):1465. DOI: 10.1007/s00134-010-1951-0.
6. Vincent JL, Moreno R, Takala J, Takala J, Willatts S, De Mendonça A, et al. The SOFA (sepsis-related organ failure assessment) score to describe organ dysfunction/failure. Intensive Care Med 1996;22(7):707–710. DOI: 10.1007/BF01709751.
7. Marshall J, Cook D, Christou N, Bernard G, Sprung C, Sibbald W. Multiple organ dysfunction score. Crit Care Med 1995;23(10): 1638–1652. DOI: 10.1097/00003246-199510000-00007.
8. Le Gall J. The logistic organ dysfunction system. A new way to assess organ dysfunction in the intensive care unit. ICU scoring group. JAMA 1996;276(10):802–810. DOI: 10.1001/jama.276.10.802.
9. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med 1985;13(10):818–829. DOI: 10.1097/00003246-198510000-00009.
10. Gall JRL, Loirat P, Alperovitch A, Glaser P, Granthil C, Mathieu D, et al. A simplified acute physiology score for ICU patients. Crit Care Med 1984;12(11):975–977. DOI: 10.1097/00003246-198411000-00012.
11. Hazelgrove J, Price C, Pappachan V, Smith G. Multicenter study of obstetric admissions to 14 intensive care units in southern England. Crit Care Med 2001;29(4):770–775. DOI: 10.1097/00003246-200104000-00016.
12. Witteveen T, de Koning I, Bezstarosti H, van den Akker T, van Roosmalen J, Bloemenkamp K. Validating the WHO maternal near miss tool in a high-income country. Acta Obstet Gynecol Scand 2015;95(1):106–111. DOI: 10.1111/aogs.12793.
13. Paternina-Caicedo AJ, Rojas-Suarez JA, Dueñas-Castel C, Miranda-Quintero JE, Bourjeily G. Mortality risk prediction with an updated acute physiology and chronic health evaluation II score in critically ill obstetric patients: a cohort study. J Intensive Care Med 2015;30(02):97–102. DOI: 10.1177/0885066613502450.
14. Muench MV, Baschat AA, Malinow AM, Mighty HE. Analysis of disease in the obstetric intensive care unit at a university referral center: a 24-month review of prospective data. J Reprod Med 2008;53(12): 914–920.
15. Karnad DR, Lapsia V, Krishnan A, Salvi VS. Prognostic factors in obstetric patients admitted to an Indian intensive care unit. Crit Care Med 2004;32(6):1294–1299. DOI: 10.1097/01.ccm.0000128549.72276.00.
16. Vasquez DN, Estenssoro E, Canales HS, Reina R, Saenz MG, Das Neves AV, et al. Clinical characteristics and outcomes of obstetric patients requiring ICU admission. Chest 2007;131(3):718–724. DOI: 10.1378/chest.06-2388.
17. Carle C, Alexander P, Columb M, Johal J. Design and internal validation of an obstetric early warning score: secondary analysis of the intensive care national audit and research centre case mix programme database. Anaesthesia 2013;68(4):354–367. DOI: 10.1111/anae.12180.
18. Paternina-Caicedo A, Miranda J, Bourjeily G. Performance of the obstetric early warning score in critically ill patients for the prediction of maternal death. Am J Obstet Gynecol 2017;216(58):e1–e8. DOI: 10.1016/j.ajog.2016.09.103.
19. World Health Organization, UNFPA, UNICEF. Trends in maternal mortality: 1990 to 2010. Geneva 2012. Available at: http://apps.who.int/iris/bitstream/10665/44874/1/9789241503631_eng.pdf, Accessed August 2018.
20. Gupta SK, Pal DK, Tiwari R, Garg R, Shrivastava AK, Sarawagi R, et al. Impact of janani suraksha yojana on institutional delivery rate and maternal morbidity and mortality: an observational study in India. J Health Popul Nutr 2012;30(4):464–471. DOI: 10.3329/jhpn.v30i4.13416.
21. Aarvold A, Ryan H, Magee L, von Dadelszen P, Fjell C, Walley K. Multiple organ dysfunction score is superior to the obstetric-specific sepsis in obstetrics score in predicting mortality in septic obstetric patients. Crit Care Med 2017;45(1):e49–e57. DOI: 10.1097/CCM.0000000000002018.