Sepsis in Obstetrics Score (SOS) utility and validation for triaging patients with obstetric sepsis in the emergency department: Evidence from a low income health care setting

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Abstract

Background: Illness severity scores commonly used in critical care settings are not considered appropriate in obstetric practice as they do not account for pregnancy physiology. A new illness severity score called the 'Sepsis in Obstetrics Score' (SOS) was introduced by Albright et al. for triaging patients with sepsis in pregnancy in an emergency department setting.

Objectives: We aimed to determine whether this score could predict the need for critical care support using the presence of organ failure as the identification criteria. Severity and culture positivity in pregnancy-associated sepsis was also assessed.

Materials and methods: All pregnant, postabortal and postpartum women with suspected sepsis were enrolled (as per systemic inflammatory response syndrome criteria) were enrolled. Severe pregnancy-associated sepsis was defined as dysfunction of one or more organs due to sepsis. The severity of pregnancy-associated sepsis was graded according to the number of organ failures. A SOS cut off of 6 was taken for statistical analysis.

Results: Out of 100 women with pregnancy-associated sepsis, 'severe sepsis' was present in 58%. When the SOS test performance was compared with the severity of pregnancy-associated sepsis, it had sensitivity of 68.9% and specificity of 80.9%, positive predictive value of 83% and negative predictive value 65% to predict severe sepsis. The area under curve for the SOS detecting severe pregnancy-associated sepsis was 0.810. SOS predicted organ failure in pregnancy-associated sepsis and this was statistically significant for all organs involved. Culture positivity did not correlate with the SOS in our study.

Conclusions: Sepsis in Obstetrics Score correlated well with organ failure in pregnancy-associated sepsis. It had a high positive predictive value (83%) for severe sepsis.

Keywords

Illness severity scores, Sepsis in Obstetrics Score, sepsis

Introduction

Illness severity scores have various applications including assessing mortality, comparisons between populations, hospital resource allocations, and as research tools.¹ Their use in the obstetric population is not well defined because of the altered physiology of pregnancy.^{1,2} Pregnancy-associated sepsis (PAS), being one of the major reasons for critical care admissions in obstetric population, has further posed challenges in priority categorization of the patients for the attending emergency clinician.

The reported incidence of PAS in high income countries varies from 12 to 35 per 100,000 deliveries with accompanying maternal mortality ranging from 0.85 to 1.13 per 100,000 maternities.^{3–6} Scenarios are worse in low income countries where PAS is one of the most common causes of maternal mortality and morbidity.⁷ Further, the critical care resources are limited and the emergency clinician needs to triage women appropriately.

Albright et al. described an emergency department scoring system, the 'Sepsis in Obstetrics Score' (SOS), designed specifically for an obstetric population, to identify the likelihood of needing critical care admission for pregnant and postpartum women who presented with signs of sepsis.⁶ The score accounts for physiological

changes occurring in pregnancy (systolic blood pressure, heart rate and leukocyte count) and incorporates parameters taken from Acute Physiology and Chronic Health Evaluation (APACHE) II and Rapid Emergency Medicine Score (REMS), i.e. temperature, heart rate, respiratory rate, oxygen saturation, and leukocyte count and the systemic inflammatory response syndrome (SIRS) criteria (systolic blood pressure, leukocyte count, percentage of immature neutrophils, and lactate) for PAS.⁶ The authors suggested that the SOS

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would aid the prioritising of patients as well as prognostication in PAS. In the original study, a SOS ≥ 6 (maximum score 28) had an area under the curve of 0.92 (sensitivity 88.9%, specificity 99.2%, positive predictive value 16.7%, negative predictive value 99.9%) for critical care admission. SOS had a relatively better positive predictive value when compared with REMS (11.1%) and Modified Early Warning Score (MEWS) (4.6%) for the risk of critical care admission in obstetric patients. Additionally, SOS ≥ 6 was independently associated with positive blood cultures and fetal tachycardia.⁶

There have been only a few other studies on the practical application of SOS, but these were retrospective in nature and all were done in high income settings.^{1,6} We therefore conducted this focused prospective study to evaluate the SOS predictability of severe sepsis and organ failure (OF) in women with PAS. The primary objective was whether SOS could possibly help in effective triage of such women in the emergency department of a low income health care setting.

Materials and methods

The prospective study (April 2015–March 2016) was conducted in the obstetric emergency department of a tertiary care health facility located in suburb of a low income country. Clearance was obtained from the Institutional Ethical Committee and prior consent was obtained from all patients. All women, who were either pregnant, within two weeks of a miscarriage or termination of pregnancy ('postabortal') or within six weeks of delivery, with suspected sepsis were investigated using SIRS/sepsis criteria (mean arterial blood pressure <65 mmHg; systolic blood pressure ≤ 90 mmHg; heart rate ≥ 110 /min; respiratory rate ≥ 22 /min; temperature $\geq 38^\circ\text{C}$ (100.4°F) or $\leq 36^\circ\text{C}$ (96.8°F); leucocyte count $\geq 14,000/\text{mm}^3$ or $<4000/\text{mm}^3$). Patients meeting ≥ 2 of above criteria were classified as having PAS/obstetric sepsis and enrolled as cases in our study (Figure 1).^{8,9} The exclusion criteria were patients with multiple or ectopic pregnancy. Severe sepsis was defined as infection-related organ dysfunction within 24 hours of

Figure 1. Statement of methodology.

SIRS: systemic inflammatory response syndrome; SOS: Sepsis in Obstetrics Score.

Table 1. Diagnostic criteria for organ failure in this study.^{*,10}

Organ system	Features (failure defined by one or more of these abnormalities)
Pulmonary	• Arterial hypoxemia ($\text{PaO}_2/\text{FiO}_2 < 300$)
Cardiac	• Increased capillary refill time or mottling
	• Arterial hypotension ($\text{SBP} < 90 \text{ mmHg}$, $\text{MAP} < 70$, or an SBP decrease $> 40 \text{ mmHg}$)
Renal	• Acute oliguria (urine output $< 0.5 \text{ ml/kg/hr}$ for at least 2 h)
	• Creatinine increase more than 0.5 mg/dl in 24 h period
Hepatobiliary	• Coagulation abnormalities ($\text{INR} > 1.5$ or $\text{aPTT} > 60\text{s}$)
	• Ileus (absent bowel sounds)
	• Thrombocytopenia (platelet count $< 100000/\mu\text{l}$)
	• Hyperbilirubinemia (plasma total bilirubin $> 4 \text{ mg/dl}$)
Neurological	• Abnormal Glasgow Coma Score

*Any of the following criteria should occur in presence of documented or suspected infection.

Table 2. Sepsis in Obstetrics Score (SOS).⁶

Variable	High abnormal range				Normal	Low abnormal range			
Score	+4	+3	+2	+1	0	+1	+2	+3	+4
Temperature ($^{\circ}\text{C}$)	> 40.9	$39-40.9$		$38.5-38.9$	$36-38.4$	$34-35.9$	$32-33.9$	$30-31.9$	< 30
SBP (mmHg)					> 90		$70-90$		< 70
Heart rate (bpm)	> 179	$150-179$	$130-149$	$120-129$	≤ 119				
Respiratory rate (bpm)	> 49	$35-49$		$25-34$	$12-24$	$10-11$	$6-9$		≤ 5
SpO_2 (%)					$\geq 92\%$	$90-91\%$		$85-89\%$	$< 85\%$
WBC ($10^3/\text{mm}^3$)	> 39.9		$25-39.9$	$17-24.9$	$5.7-16.9$	$3-5.6$	$1-2.9$		< 1
% immature neutrophils			$\geq 10\%$		$< 10\%$				
Lactate (mmol/l)*			≥ 4		< 4				

*Venous samples.

admission.¹⁰ The criteria used to diagnose 'organ failure' are listed in Table 1.

Separate documentation of patient's parameters was done according to the SOS criteria (Table 2). The patients were distributed into two groups based on proposed SOS cut off of 6; group I < 6 and group II with $\text{SOS} \geq 6$.⁶ We used the development of OF as a marker of the need for critical care.¹⁰

Detailed clinical, pertinent laboratory, and imaging tests were performed for all enrolled patients. Blood, high vaginal swab, and pus (if present) were sent for bacterial culture and sensitivity. We considered the woman culture positive if single microbial growth was isolated in any of the samples. Venous lactate levels were obtained along with other hematological investigations at admission. The choice of venous sample for lactate estimation was based on the recent NICE guidelines which have considered venous values almost equivalent to arterial samples.¹¹ For OF assessment, the following key body systems were assessed and monitored: pulmonary, cardiac, renal, hepatobiliary, and neurological systems. Patients were further managed as per hospital protocol and at the physicians' discretion.

The sample size of 100 PAS patients was based on a convenience basis as no previous study on SOS applicability has been performed in this world region. Due to the non normal distribution and small sample size, non-parametric statistical tests were used to analyze severity of PAS, number of OFs and culture positivity within the two SOS groups. The comparison between severe and non-severe PAS was made using Mann Whitney U test. The correlation between a SOS cut off of 6 and OF was determined using Spearman coefficient. SOS

correlation with culture positivity was calculated using Fisher Exact test. Area under curve (AUC) graphs were plotted to see SOS estimation of severe sepsis.

Results

Our study population largely comprised of young women of 20–29 years (mean 26.0 ± 4.6 years). Out of 100 PAS women, 9% were postabortal, 24% antepartum, and 67% postpartum. Severe sepsis was detected in 58% of subjects with 5 (8.6%), 13 (22.4%), and 40 (68.9%) patients in the postabortal, antepartum, and postpartum categories, respectively. Various clinical and laboratory parameters are detailed in Figure 2. Clinical parameters of systolic blood pressure $\leq 90 \text{ mmHg}$ ($p < 0.0005$) and oxygen saturation SpO_2 ($< 92\%$) ($p < 0.0005$) were found to be most significant for prediction of severe sepsis. Among laboratory parameters, raised serum lactate ($\geq 4 \text{ mmol/l}$) was significantly higher in severe sepsis ($p < 0.0005$).

Sepsis with positive blood cultures was seen in 28% followed by urinary tract infection (urine culture positive) in 22% and genital infection (high vaginal swab culture positive) in 19% of cases as tabulated in Table 3. Overall rate of culture positivity (any culture positive) was seen in 35% subjects with PAS. The most common organism identified in positive blood and genital cultures was *Staphylococcus aureus*. The majority of severe PAS cases had pulmonary involvement (35%) followed by hepatobiliary, renal, cardiovascular, and nervous system. We observed single OF in 23 cases, two OF in 12 cases, and ≥ 3 OF in 23 cases in the enrolled patients.

Figure 2. Correlation of clinical and laboratory parameters of PAS subjects in non-severe and severe sepsis. PAS: pregnancy-associated sepsis. $p > 0.0005$.

Table 3. Culture positivity in PAS.

Organism involved	No. of culture positive
Blood	28
<i>Staphylococcus aureus</i>	24 (85.7%)
MRSA	3 (10.7%)
<i>Klebsiella pneumoniae</i>	1 (3.6%)
UTI/Urine	22
<i>Escherichia coli</i>	15 (68.2%)
<i>Candida albicans</i>	7 (31.8%)
Genital infection/HVS+ve	19
<i>Staphylococcus aureus</i>	16 (84.2%)
<i>Escherichia coli</i>	2 (10.5%)
<i>Acinetobacter</i>	1 (5.3%)
Wound infection	2
<i>Escherichia coli</i>	1 (50%)
<i>Citrobacter</i>	1 (50%)

HVS: high vaginal swab; MRSA: methicillin-resistant *Staphylococcus aureus*; PAS: pregnancy-associated sepsis; UTI: urinary tract infection.

SOS and the severity of PAS

Group I (SOS < 6) had 52 and group II (SOS ≥ 6) had 48 cases of PAS. Overall SOS score ranged from 1 to 22 in PAS subjects with a mean of 6.49 ± 4.25 . Non-severe PAS had a mean SOS (4 ± 2.65 ;

Table 4. Relationship between SOS score with severity of PAS.

	Non-severe sepsis (n = 42)	Severe sepsis (n = 58)	p value
Group I (SOS < 6)	34 (65.4%)	18 (34.6%)	<0.0005
Group II (SOS ≥ 6)	8 (16.7%)	40 (83.3%)	

PAS: pregnancy-associated sepsis; SOS: Sepsis in Obstetrics Score.

range up to 14) significantly lower than severe PAS (mean 8.29 ± 4.30 ; range up to 22) ($p < 0.00001$). A SOS score of ≥ 6 was present in 83.3% (40/58) of patients with severe sepsis (Table 4). An SOS cut off of 6 (Table 4) predicted severe PAS with a sensitivity of 68.9% and specificity of 80.9%, positive predictive value of 83.3% and negative predictive value 65.3%. The AUC for SOS detecting severe PAS was 0.810 (Figure 3). The best SOS diagnostics for our obstetric population were probably at cut off of 4 (sensitivity 87.9% to 79.3%; specificity 45.2% to 64.3%) for detection of severe sepsis. With raised SOS values, the sensitivity decreased at cost of specificity.

SOS and OF

Of the 58 women with OF, 69% ($n = 40$) were in group II and 31% ($n = 18$) in group I ($p < 0.0005$) (Tables 5 and 6). Of these 40 women in group II, 32.5% had one OF, 17.5% had two OF, and 50% had multiorgan failure (>2 OF). There was statistically significant (p value < 0.0005) increased involvement of all organs seen in group II

Figure 3. The area under curve (AUC) for SOS detecting severe PAS was 0.810. ROC: receiver–operator characteristic curve.

compared to group I. The most common system involved in both groups was the pulmonary system which was seen in 27 subjects of group II and eight subjects in group I. Thus a SOS cut off of 6 predicted OF in PAS and this was statistically significant for all organs involved. The Spearman correlation coefficient for SOS using cut off of 6 and OF was found to be 0.614 ($p < 0.0005$).

SOS and culture positivity

With overall culture positivity in 35 cases, 18 were in group I and 17 in group II and the difference was not significant ($p = 0.208$).

Discussion

Illness scoring systems in sepsis patients are a valuable tool for risk assessment and prognostication.¹ There are many validated illness scoring systems available for common clinical use, e.g. APACHE, Simplified Acute Physiology Score (SAPS), Sequential Organ Failure Assessment (SOFA), etc. However, their use is mainly focused on predicting mortality in patients already admitted in critical care units.

Low income countries have a unique situation in form of high rate of obstetric sepsis and limited critical care health resources. It therefore becomes important to use the available health resources judiciously. Thus, in contrast to mortality calculations in a critical care unit, triaging of patients with PAS for admission to critical care unit

remains a major dilemma for the emergency clinician working in such situations. More recently, identification of organ dysfunction has become more significant than admission to critical care unit as organ-specific care bundles have shown better outcomes.^{1,10}

The SOS score, the PAS specific scoring system, was proposed by Albright et al. in 2014 based on 850 women evaluated retrospectively.⁶ Although shown to be a good emergency triaging index for obstetric sepsis, the above study had limitations including a lack of mortality data, a retrospective study design and high percentage of missing parameters (23%) in evaluated patients, creating high chances of bias. The authors themselves vowed for a prospective evaluation of SOS.⁶ Aarvold et al. recognizing the limitations of above study, evaluated the SOS in a multicenter obstetric population with sepsis ($n = 146$) and compared it to four scores: APACHEII, SAPSII, SOFA, and Multiple Organ Dysfunction Scores (MODS) for mortality-related outcomes following critical care admissions.¹ The study also had a non-obstetric, age-matched control cohort ($n = 299$). The SOS, APACHE II, SAPS II, SOFA, and MODS scores gave area under the receiver–operator characteristic curves of 0.67, 0.68, 0.72, 0.79, and 0.84 for prediction of mortality in the obstetric cohort, respectively, and 0.64, 0.72, 0.61, 0.78, and 0.74 for prediction of mortality in the non-obstetric cohort, respectively. In the obstetric population the OF based severity of illness scores, such as MODS, was the best performing mortality predictor for this study.¹ The predictive value of SOS with respect to mortality although poor was comparable to SAPS II and APACHE II scores. The study suggested

Table 5. SOS correlation with organ failure.

No. of organ failure	Group I: (SOS <6) (patient <i>n</i> = 52)	Group II: (SOS ≥6) (patient <i>n</i> = 48)
Organ failure (<i>n</i> = 58)	18	40
1 (<i>n</i> = 24)	11 (61.1%)	13 (32.5%)
2 (<i>n</i> = 11)	4 (22.2%)	7 (17.5%)
3 (<i>n</i> = 11)	1 (5.6%)	10 (25%)
4 (<i>n</i> = 4)	0 (0.0%)	4 (10%)
5 (<i>n</i> = 8)	2 (11.1%)	6 (15%)
Types of organ failure (total number of organ failures, <i>n</i> = 135)		
Cardiovascular	3 (2.2%)	21 (15.6%)
Hepatobiliary	9 (6.7%)	18 (13.3%)
Nervous	3 (2.2%)	19 (14.1%)
Pulmonary	8 (5.9%)	27 (20%)
Renal	9 (6.7%)	18 (13.3%)

SOS: Sepsis in Obstetrics Score.

Table 6. Correlation of SOS with number of organ failure (OF).

SOS: Score value	Nil OF (<i>n</i> = 42)	1 OF (<i>n</i> = 24)	2 OF (<i>n</i> = 11)	3 OF (<i>n</i> = 11)	≥4 OF (<i>n</i> = 12)
Range	1–14	1–11	3–17	5–22	4–20
Mean ± SD	4 ± 2.65	6.17 ± 3.16	8.42 ± 3.99	10.09 ± 4.59	11 ± 4.83

SOS: Sepsis in Obstetrics Score.

that organ-based scoring systems may be more useful than physiological-based systems in obstetric sepsis.¹ The limitations of this study included the retrospective study design, the use of SOS for predicting mortality rather than emergency triage as in our study, and the use of a modified SOS which excluded the immature neutrophil count.

Our study inferred a low sensitivity (68.9%), a better specificity (80.9%), and a high positive predictive value (83%) for SOS (at a cutoff score of 6) predicting severe sepsis. Caution is required here as the PPV values from SOS/REMS/MEWS scores in published literature were based on actual numbers admitted to level 1 critical care units.⁶ The present study was limited to the emergency department only and many of these patients although having OF (e.g. renal dysfunction) might be well managed in a level 2 critical care unit/high dependency units. The SOS diagnostic cut-off to detect severe sepsis was best around 4 for our health care setting with a high number of severe sepsis patients. Another inference from our study was that SOS ≥6 was statistically valid in predicting all types of OFs compared to lower scores. However, culture positivity was not well correlated to SOS as seen in previous study.

Our study was conceptualized prior to the introduction of the new Sepsis-3 guidelines which now do not include the description 'severe sepsis'.¹² It will take some time before new research and national health care planning will be performed according to the new 'sepsis' definition.¹³ Another limitation was the lack of prospective follow-up of the patients after critical care admission to evaluate the outcome in terms of mortality or final outcome. This was also beyond the scope of our study as we aimed to measure SOS as a triage tool for PAS in the obstetric emergency department rather than in patients already admitted to critical care units. Furthermore, other scores such as REMS and MEWS were not measured in our study. Since patients with PAS/severe sepsis are small in number, the obstetric group with sepsis on the whole was considered a single entity to ensure an adequate sample size. As such, the physiological difference

in pregnant, postabortal (2 weeks), and postpartum women (up to 6 weeks) were not accounted for in this study. Being a pilot study with a sample size of convenience, it is also possible that many of the statistical results were underpowered. The limitation of interpretation of PPV is already explained above.

The options for scoring systems available for triage of PAS (with all its complexities) patients in emergency department are still scanty. The depicted PPV of other existing systems (REMS: 11.1%, MEWS: 4.6%)⁶ for risk of critical care admission in obstetric sepsis is again limited. This is the first application of SOS in a population from a low income country with high sepsis rate. Our study added to the evidence that the SOS score had robust diagnostic powers to differentiate severe PAS (esp. occurrence of organ failures) from non-severe PAS. Looking to the grave situation of PAS related maternal morbidity and mortality in low income countries, it can be of potential value in emergency department for triaging and allocating the critical care beds. We however strongly recommend further substantiation of SOS utility and validation in obstetric sepsis. There also seems to be a need to refine the currently defined cut off values of SOS. The key to PAS management lies in rapid and accurate identification of patients as early initiation of therapy improves outcome. Thus, there is a strong need to develop better scoring systems for application in obstetric sepsis.

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Guarantor

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Contributorship

RA: Concept, design, definition of intellectual content, manuscript preparation, manuscript editing and manuscript review. She takes public responsibility for the appropriateness of the manuscript content. RKY: Literature search, experimental studies, data acquisition, data analysis, statistical analysis. MM: Concept, design, definition of intellectual content, manuscript preparation, manuscript editing and manuscript review. MS: Concept, design, definition of intellectual content, manuscript preparation, manuscript editing and manuscript review. GR: Concept, design, definition of intellectual content, data analysis, manuscript preparation, manuscript editing and manuscript review.

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