ORIGINAL RESEARCH ARTICLE

Routine Screening for Sepsis in an Obstetric Population: Evaluation of an Improvement Project

Holly A Champagne, DNP, RN; Matthew J Garabedian, MD

Perm J 2020;24:19.232

E-pub: 12/2/2020

https://doi.org/10.7812/TPP/19.232

ABSTRACT

Introduction: Our objectives were to calculate the timeliness of treatment following implementation of routine sepsis screening in an inpatient obstetric population using obstetric-adjusted systemic inflammatory response syndrome (SIRS) criteria, evaluate the performance of obstetric-specific screening criteria in the identification of sepsis, and to better characterize the frequency of end-organ dysfunction associated with those who met the definition of sepsis.

Methods: Electronic medical record data were collected from all pregnant or newly delivered women admitted for observation, admission, or postpartum readmission in the hospital maternity unit from March 1 through December 31, 2017 (n = 5075). Combinations of SIRS criteria were collected and compared with clinical indicators of end-organ dysfunction in those who met the definition of sepsis. Maternal conditions and neonatal outcomes were evaluated.

Results: In the study period, 204 cases of sepsis were identified among 201 women, 2 of whom experienced multiple episodes of sepsis, resulting in an incidence of sepsis of 4.0 per 100 livebirths. There were 92 (45.2%) with sepsis and 112 (54.9%) with end-organ dysfunction. Two women were admitted to the intensive care unit and no women died from sepsis.

Discussion: Use of a standardized, obstetric-specific sepsis screening process provided for early identification and treatment of sepsis in this population. Fourteen unique combinations of SIRS criteria were noted among those with sepsis; no combination was uniquely associated with the severity of sepsis.

Conclusion: Pregnant and newly delivered women benefitted from implementation of routine sepsis screening; this resulted in timely initiation of treatment.

INTRODUCTION

There is growing attention to the morbidity and mortality associated with sepsis, which remains the second leading cause of maternal death in the United States.[1] The rate of severe maternal sepsis morbidity and mortality in the United States rose between 1998 and 2008.[2] The Surviving Sepsis Campaign guidelines resulted in significant decreases in sepsis-related mortality in the adult nonpregnant population.[3] However, these guidelines fail to account for the normal physiologic changes of pregnancy. Although evidence-based standardization of preeclampsia and obstetric hemorrhage care has decreased mortality for women with those conditions,[4] sepsis in the maternity population has not yet received the same national attention.

Routine sepsis screening and treatment in the adult, nonobstetric population was a standardized practice in our facility's emergency department and intensive care units (ICUs) before the initiation of this project. The inpatient obstetric units lacked a standardized screening process because of multiple factors. There is no nationally accepted standard for sepsis screening in the maternity population; therefore, there was no established process to screen patients for sepsis in the maternity units. There was a lack of consensus among the clinical staff about the applicability of standardized sepsis treatment bundles in the obstetric patients. In particular, there were concerns about providing a large intravenous fluid bolus to a woman with preeclampsia and lack of agreement on the utility of lactic acid as a marker of end-organ dysfunction. The lack of a systematic method to identify and treat sepsis in this population was recognized as a potential threat to patient safety by facility interdisciplinary perinatal and sepsis quality improvement.

The third International Consensus definitions for sepsis and septic shock (Sepsis-3) recommend the use of a quick Sequential (Sepsis-related) Organ Failure Assessment score (qSOFA) as a prompt to begin evaluation for end-organ dysfunction.[5] However, it lacks diagnostic utility in the obstetric population, with a 50% sensitivity.[6] Although recent literature has indicated that there are potential modifications of qSOFA for use in the obstetric population,[7,8] those recommendations were published after the initiation of this project.

The Centers for Medicare & Medicaid Services Early Management Bundle, Severe Sepsis/Septic Shock core measure (SEP-1), uses the presence of 2 or more systemic inflammatory response system (SIRS) values as a component of the definition of severe sepsis.[9] SIRS criteria have been used in past screening tools to prompt evaluation for the presence of infection. Clinicians caring for adults at the study site rely on SIRS criteria to screen for sepsis per facility guidelines. In the nonobstetric adult population, there are widely accepted clinical criteria to define SIRS.[10]

A challenge with applying adult SIRS criteria to pregnant women stems from the normal physiologic changes that

Author Affiliation
Kaiser Permanente, Women's and Children's Hospital, Roseville, CA

Corresponding Author
Holly A. Champagne, DNP, RN (holly.a.champagne@kp.org)

Keywords: apgar, chorioamnionitis, lactic acid, obstetric infection, improvement, maternal morbidity, safety, sepsis, screening, SIRS

occur in pregnancy. Physiologic changes of pregnancy mimic those seen with sepsis in a nonpregnant population. Maternal heart rate, respiratory rate, and white blood cell (WBC) count are usually elevated during pregnancy.[11] Modifications of the standard adult SIRS screening criteria have recently been proposed to account for the normal changes of pregnancy to identify triggers for sepsis evaluation.[11-15] Fetal tachycardia is an additional marker of systemic response and is variably used as a sign of maternal sepsis.[15-18] Given there is no single presentation of sepsis in the obstetric population,[19] clinical suspicion and a combination of clinical signs must be used for early detection.

In an effort to improve the identification and treatment of sepsis in our inpatient obstetric population, we instituted routine use of a Maternal Sepsis Screening Pathway in February 2017. A second objective was to meet the SEP-1 requirements. The process implemented was designed to meet requirements put forth by this measure. The purpose of this paper is to report on the timeliness of treatment provided as a result of this program, the frequency of obstetric sepsis identified using the Maternal Sepsis Screening Pathway guidelines, and to evaluate the performance of obstetric-specific screening criteria following program implementation. Maternal and neonatal complications and the type and frequency of end-organ dysfunction present in this population will also be described.

METHODS

Guidelines for treatment of sepsis were created in association with the facility's committees related to sepsis and to perinatal patient safety and obstetric and maternal-fetal medicine specialists. Care was provided per the clinical judgment of the individual provider. Patient data were collected and abstracted from the electronic medical record and facility reports. Data were deidentified and stored in a confidential manner.

Approximately 6000 births occur annually at the study site, which is a tertiary care center located in a suburban setting in the western United States. Training of the obstetric physicians, certified nurse midwives, and nursing staff caring for patients in the ante-, intra-, and postpartum units took place before implementation of the Maternal Sepsis Screening Pathway program. Program leaders were visible champions of the initiative and included a maternal-fetal medicine physician, obstetric unit nurse managers, and endorsement by facility sepsis and perinatal patient safety committees.

The Maternal Sepsis Screening Pathway program uses obstetric-adjusted SIRS criteria to prompt evaluation for sepsis in the obstetric inpatient population. The obstetric SIRS criteria used in this study included a higher maternal heart rate, respiratory rate, and WBC count than are used with standard adult sepsis SIRS criteria. Two other California health care systems use obstetric-adjusted values in their maternal sepsis screening criteria.[15,20] Our criteria are consistent with those health care systems and with Barton & Sibai.[13] Fetal tachycardia was included as a marker for fetal response to infection. The remaining standard adult SIRS criteria were used without modification (Table 1).

Routine screening was completed by the obstetric nurse at the time of the patient's presentation to triage, upon admission, and once per shift. Women with an antepartum admission or postpartum readmission were also routinely screened. The presence of altered mental status, or 2 or more SIRS criteria, act as a trigger for the nurse to confer with the obstetric provider (either an obstetrician or certified nurse midwife). Clinical evidence of SIRS prompted further assessment for infection by the obstetric provider.

The SEP-1 guidelines define severe sepsis as the presence of a source of infection, 2 SIRS criteria, and end-organ dysfunction.[9] The working definition of sepsis for the Maternal Sepsis Screening Pathway was modified from the institutional adult sepsis protocol and based on SEP-1 and the 2016 Surviving Sepsis Campaign guidelines.[21] In this pathway, sepsis was defined as a positive SIRS screen and a suspected source of infection.

Initial evaluation included clinical assessment and laboratory assessment (complete blood count, lactic acid, bilirubin, activated partial thromboplastin time [APTT], blood culture, urinalysis, chemistry panel). Cases of sepsis were further categorized as: 1) sepsis, if there was no evidence of end-organ dysfunction; 2) severe sepsis, with evidence of end-organ dysfunction; or 3) septic shock in the presence of a markedly elevated lactic acid level or if hypotension was present and persisted despite volume resuscitation (Table 2). Evaluation and stratification of severity of sepsis and treatment guidelines were determined in collaboration with the facility committee on sepsis, the facility perinatal patient safety committee, and in keeping with the treatment guidelines included in the SEP-1 initiative. In the Maternal Sepsis Screening Pathway, assessment of end-organ dysfunction largely mirrors that used in the adult nonobstetric population (Table 2). Creatinine values were adjusted to reflect the lower values that are present in the obstetric population as a result of the physiologic changes of pregnancy.

Initial management included administration of intravenous fluids and administration of antibiotic or antiviral medication, as indicated by the specific suspected infection. Evidence-based recommendations for patient care were provided, but individual care was left to the discretion of the obstetric provider. Intravenous fluid resuscitation, either 2 L of normal saline or 30 mL/kg of body weight, was indicated for the diagnosis of severe sepsis or septic shock.

Table 1. Systemic Inflammatory Response Syndrome values adjusted for an obstetric population

Variable	Adult, nonobstetric population[a]	Adjusted for obstetric population
Altered mental status	Present	Same value
Temperature		
Low	> 100.4°F (38°C)	Same value
High	< 96.8°F (36°C)	Same value
Heart rate	> 90 bpm	> 110 bpm
Respiratory rate	> 20 breaths per minute	> 24 breaths per minute
White blood cell count (mL)		
Low	< 4000	Same value
High	> 12,000	> 15,000
Bands	> 10% bands	Same value
Fetal heart rate	Not included	> 160 bpm for 10 min

Comparison to adult, nonobstetric population values.
bpm = beats per minute.
[a] Adult, nonobstetric Systemic Inflammatory Response Syndrome values from previous work.[7]

Documentation of the nurse's sepsis screen was contained in a note in the patient's electronic medical record (EMR), During the study period, 2 spot checks were performed to ensure that the sepsis screens were taking place. Checks were completed 1 and 7 months following implementation. All inpatient obstetric patient EMRs were checked for presence of screening documentation. In both sets of checks, every patient had a record of a screen performed, with greater than 80% having a screen documented during each shift the patient was an inpatient.

Audits of patient EMRs were determined to be the best method to evaluate for frequency of the presence of sepsis, which SIRS criteria were present at the time of the diagnosis, and which markers of end-organ dysfunction were present. During implementation, it was noted that there was a preponderance of sepsis cases identified during the active phase of labor, and that the most common source of infection was chorioamnionitis. Stage of labor, the source of infection, and placenta pathology results were evaluated to better describe the patterns of sepsis occurring in our population.

Data reports were run from the facility EMRs to evaluate the medical records of all inpatient women who were pregnant, postpartum, or who experienced a postpartum readmission. Administrative reports identified those who had a lactic acid level drawn and those who had a diagnosis of infection or sepsis during the study period. Three women who had received interventions for sepsis and then transferred to our unit from another facility were excluded. For women with multiple hospitalizations for sepsis, each event was considered independently. Neonatal data were linked to the intrapartum event for all sepsis cases.

Data were abstracted from the EMR (H.C.) during the study period, March 1 through December 31, 2017. The obstetric-adjusted SIRS criteria and a suspected source of infection were identified through record review. Neonates born to women with intrapartum sepsis during labor were identified. Maternal and neonatal data were linked. The EMR of each neonate was reviewed, and data were abstracted. Demographics of women who screened positive were compared against the total delivery population. Additionally, Apgar scores were compared against hospital-wide data from all newborns delivered during the study period.

Manual chart review was performed to determine diagnosis, maternal clinical findings, and neonatal outcomes. Altered mental status was defined as a reported or noted change in her baseline cognitive state or level of consciousness. Maternal temperature; WBC count, including bands; respiratory rate; heart rate; and fetal heart rate (FHR), blood pressure, and mean arterial pressure (MAP)

Table 2. Severity of sepsis criteria with defined end-organ dysfunction categories used in the Maternal Sepsis Screening Pathway

End-organ dysfunction	Sepsis	Severe sepsis	Septic shock
Systolic blood pressure (mmHg)		< 90[a]	< 90[b]
Mean arterial pressure		< 65	< 65 [b]
Urine output		≤ 30 mL/h for 2 h	
APTT		> 60 s	
Creatinine		≥ 1.5 mg/dL	
Bilirubin		> 2 mg/dL	
Lactic acid (mmol/L)	< 2.0	2.0-3.9	> 3.9
Platelet count (10^9/L)		< 100,000	

APTT = activated partial thromboplastin time.
[a] Must be at least 5 mmHg lower than patient's baseline rate.
[b] Following fluid resuscitation.

were evaluated for the presence of SIRS criteria. When the MAP was not noted, it was calculated from the recorded blood pressure closest to the time the 2 SIRS criteria were present. Those who met the SIRS inclusion criteria had their records evaluated for a documented presence of infection. Once the individual met the diagnosis of sepsis (ie, 2 SIRS criteria and a suspected source of infection were present), data were abstracted for that individual.

Vital sign data were those obtained within 30 minutes of the time when a positive SIRS screen was identified. The WBC count value used as a SIRS criterion was antecedent to the diagnosis of sepsis and not the one drawn in response to a positive sepsis screen. The laboratory values for end-organ dysfunction were those recorded at the time of SIRS criteria being met, or within 1 hour before that time.

Laboratory testing was deferred until after birth for those who screened positive in the second stage of labor. Sepsis was determined to occur in the postpartum period if orders for laboratory tests and antibiotics were placed at least 2 hours following delivery. Facility guidelines recommend obtaining placental pathology for a variety of clinical indications, including all cases of sepsis that occur before or immediately following birth. Histologic evidence of chorioamnionitis included placentas with a diagnosis of funisitis and fetal surface vasculitis. Placental culture was not routinely requested, but performed at clinician's request.

Descriptive statistics were used for demographic and clinical characteristics data. Chi-squared testing was used to measure association with categorical variables. Odds ratios and 95% confidence intervals (95% CIs) were calculated for dichotomous variables.

RESULTS

During the 10-month study period, 5075 women gave birth at the site. In total, 204 cases of sepsis were identified in 201 women (2 women had multiple incidents of sepsis). The observed incidence rate of obstetric sepsis was calculated at 4.0 per 100 births. All inpatient obstetric patients who were antepartum, intrapartum, postpartum, or experienced a postpartum readmission for sepsis were included in the calculation of the incidence of sepsis because all would have received routine screening.

Antibiotics were administered to those with a diagnosed bacterial source of infection (n = 202, 99%). Of those, 145 women (72%) received antibiotics within 1 hour of a sepsis diagnosis and 186 (92%), within 3 hours. Adequate fluid resuscitation was provided to 69% of the women with severe sepsis or septic shock. An additional 12 women (6%) received a 1-L intravenous fluid bolus.

No maternal deaths from sepsis occurred during the study period. Neither admission to the ICU (n = 2, 1.0%) nor development of pulmonary edema (n = 3, 1.5%) was common among women with sepsis. No pulmonary edema resulted from administration of fluid resuscitation ordered for treatment of severe sepsis or septic shock.

Most women (n = 146, 71.6%) developed sepsis during the intrapartum phase of pregnancy; of the others, 35 (10.2%) during postpartum, 13 (6.4%) as antepartum admissions, and 10 (4.9%) during a postpartum readmission. Twenty women (10.2%) developed SIRS-positive criteria immediately before delivery, or up to 3 hours postdelivery. Of all women with sepsis, most (n = 181, 88.7%), developed SIRS-positive criteria during the hospitalization, the rest were septic at the time of admission to the triage observation area (n = 23, 11.3).

Out of the 204 cases of sepsis, 92 (45.1%) met sepsis criteria, 87 (42.6%) met severe sepsis criteria, and 25 (12.3%) met septic shock criteria. In most cases (n = 189, 92.6%), the lactic acid result defined the severity of sepsis. Of the 15 women who met severe sepsis or septic shock criteria for a reason other than an elevated lactic acid level, 7 (46.7%) had decreased urine output, 4 (26.7%) had a creatinine level >1.5 mg/dL, 3 (20%) had a systolic blood pressure of 90 mmHg or less, and 1 (6.7%) had a MAP < 65 mmHg. Three women (20%) with a mean arterial pressure < 65 mmHg also met the initial low blood pressure criteria with systolic blood pressures < 90 mmHg (Table 3).

Not all of the laboratory tests listed on the Maternal Sepsis Screening Pathway were ordered; notably, APTT was ordered in 56 (27.4%) of cases and bilirubin in 93 (45.6%) of cases. No women met the severity criteria for elevated bilirubin level, platelet count less than 100,000 10^9/L, elevated APTT, nor systolic blood pressure decrease of less than 40 mmHg from her baseline blood pressure. No woman met septic shock criteria by having persistent hypotension following fluid resuscitation.

Women with sepsis were more likely to have a history of prior cesarean delivery (p = .01), or be primigravid (p = .01). Those with sepsis were more likely to have anemia when compared with women with severe sepsis or septic shock (p = .01) (Table 4). There were no statistical differences of other maternal characteristics for women when stratified by the severity of sepsis. Obstetric provider documentation supplied information as to the suspected source of infection. Chorioamnionitis was the most frequently diagnosed infection (n = 128, 62.7%). Of those cases of chorioamnionitis, 24 (15.8%) were not confirmed on placental pathology. Endomyometritis was the second most frequent diagnosis (n = 21, 10.3%), followed by urinary tract infection or pyelonephritis (n = 12, 5.9%). Six (2.9%) individuals had 2 diagnoses: 2 with pyelonephritis and pneumonia (1%), 3 (1.5%) with chorioamnionitis and a urinary tract infection, and 1 (0.5%) with a pelvic abscess and endomyometritis. Two women (1%) had upper

Table 3. Clinical values present which determined the severity of sepsis in women with a diagnosis of sepsis (N = 204)

Values present	n (%)	Sepsis severity
Lactic acid < 2.0 mmol/L	92 (45.1)	Sepsis
and serum creatinine ≥ 1.5 mg/dL	2 (1.0)	Severe sepsis
and urine output ≤ 30 mL/h for 2 h	4 (2.0)	Severe sepsis
and MAP < 60 mmHg	1 (0.5)	Severe sepsis
Lactic acid 2.0-3.9 mmol/L	75 (36.8)	Severe sepsis
and serum creatinine ≥ 1.5 mg/dL	2 (1.0)	Severe sepsis
and urine output ≤ 30 mL/h for 2 h	2 (1.0)	Severe sepsis
and systolic blood pressure < 90 mmHg and MAP < 65 mmHg	1 (0.5)	Severe sepsis
Lactic acid > 3.9 mmol/L	22 (10.8)	Septic shock
and urine output ≤ 30 mL/h for 2 h	1 (0.5)	Septic shock
and systolic blood pressure < 90 mm and MAP < 65 mmHg	2 (1.0)	Septic shock

MAP = mean arterial pressure.

respiratory infections. Three (1.5%) had no documented source of infection and received antibiotics and fluids per the pathway guidelines. The remaining infections were 1 each of the following: abdominal source, fever of unknown origin, influenza, mastitis, pneumonia, vulvar cellulitis, and a viral gastrointestinal disorder.

Of the women in labor, 36 (17.6%), developed positive SIRS criteria when they were dilated between 0 and < 6 cm, 58 (28.4%), between 6 cm and < 10 cm, and 52 (25.5%) at complete dilatation. The length of time for rupture of membranes for those in labor (n = 146) ranged from women with intact membranes (n = 13) to 1 who had membranes ruptured greater than 9 days. The remaining 132 women had lengths of time of ruptured membranes ranging from 1 minute to 79 hours, with a mean of 14.5 hours, 95% CI (12.5-16.5), median of 12.1 hours, and standard deviation (SD) = 11.8 hours. There was no association noted between lactic acid levels and the length of time of ruptured membranes. There were 14 unique combinations of SIRS criteria associated with the women with the diagnosis of sepsis (Table 5). None had altered mental status at the time of the SIRS positive screen. No women had a temperature < 36°C, or a WBC count < 4000 × 10^9 /L, or > 10% bands concurrent with another SIRS criterion. Most women (n = 147, 72%) met the definition of sepsis with 2 positive screening criteria; however, 48 women (23.5%) had 3 positive criteria and 9 (4.4%) had 4 positive criteria at diagnosis. The most frequent combinations of SIRS criteria were maternal fever in combination with elevated maternal heart rate (n = 124, 60.8%), fetal tachycardia (n = 74, 36.3%), or elevated maternal WBC count (n = 45, 22.1%). There was no statistical difference noted among the 14 SIRS combinations and the severity of sepsis, regardless of the number of positive screening criteria. Fifty-one women who were pregnant (32.3%) were identified as SIRS-positive with FHR tachycardia, in association with 1 other SIRS criterion. Of these, 24 (15.2%) had a significantly elevated lactic acid level.

There were occasions in which the obstetric provider ordered lactic acid values when the patient had fewer than 2 SIRS criteria present at the time of sepsis screening. Data review revealed that women who did not initially meet SIRS criteria, but who had lactic acid levels ≥ 2.0 mmol/L, developed 2 SIRS criteria within 3 hours of the initial lactate collection, with 1 exception. One woman (0.5%) with an initial temperature of 39.3°C, with a diagnosis of endomyometritis, and positive blood cultures for *Pseudomonas putida*, never developed a second SIRS criterion.

Blood cultures were collected on 153 (75%) of the women identified with sepsis. Five of the blood cultures collected had positive results. There were 69 urine cultures collected. Of those 69, 18 (26.1%), were positive. Four women (2.0%) diagnosed with pyelonephritis or urinary tract infections had negative urine cultures. Six women (2.9%) with positive urine cultures had nonurinary tract sources of infection listed: 5 with chorioamnionitis or endomyometritis (4.9%) and 1 without a listed source of infection (0.5%).

Placental examination by a pathologist occurred in 144 (79.6%) cases of those diagnosed with sepsis during labor or postpartum (n = 181). Of the 144 placentas sent for examination, 109 had histological evidence of chorioamnionitis, and 2 were positive for bacterial growth. Positive placental findings were associated with a diagnosis of chorioamnionitis (n = 102, 93.6%), endomyometritis (n = 4, 3.7%), and pyelonephritis or urinary tract infection (n = 2, 1.8%).

In the women with all forms of sepsis, 161 (79.0%) women had creatinine values recorded at the time of the diagnosis of sepsis. Of these, 52 (32.3%) had a creatinine ≥ 0.8 mg/dL. There was statistical significance noted in the

Table 4. Demographic, obstetric factors, and co-morbidities in women with sepsis diagnosis compared to those who met severe sepsis or septic shock criteria (N =204)

Demographic, delivery, and risk factors	Sepsis n (%)	Severe sepsis or septic shock n (%)	p
Age (y)			0.08
< 20	7 (3.4)	1 (0.5)	
20-30	48 (23.5)	57 (27.9)	
30-39	34 (16.7)	51 (25.0)	
≥ 40	3 (1.5)	3 (1.5)	
Race			0.22
Asian/Pacific Islander	16 (7.8)	33 (16.2)	
Black/African American	10 (4.9)	8 (3.9)	
Hispanic	16 (7.8)	23 (11.3)	
White	48 (23.5)	45 (22.1)	
Other/decline to state	2 (1.0)	3 (1.5)	
Parity			0.01
0	56 (27.5)	87 (42.6)	
≥ 1	36 (17.6)	25 (12.3)	
Cesarean delivery history			
Yes	12 (5.9)	4 (2.0)	0.02[a]
No	80 (39.2)	108 (52.9)	
Fetal death			0.59 [a]
Yes	2 (1.0)	1 (0.5)	
No	90 (44.1)	111 (54.4)	
Gestational age (n = 181)			0.18
< 37 weeks	12 (6.6)	10 (5.5)	
≥ 37 weeks	63 (34.8)	96 (53.0)	
Twin gestation			0.84
Yes	2 (1.0)	2 (1.0)	
No	90 (44.1)	110 (53.9)	
Delivery type (n = 190)			0.24
Vaginal	50 (26.3)	58 (30.5)	
Cesarean section	31 (16.3)	37 (.19.5)	
VAVD	3 (1.6)	7 (3.7)	
Forceps	0 (0)	4 (2.1)	
Anemia[b]			0.01
Yes	26 (12.7)	16 (7.8)	
No	66 (32.4)	96 (47.1)	
Asthma			0.53
Yes	6 (2.9)	10 (4.9)	
No	86 (42.2)	102 (50.0)	
Body mass index (n = 203)			0.78
Normal (18.5-24.9)	8 (3.9)	6 (3.0)	
Overweight (25.0-29.9)	29 (14.3)	33 (16.3)	
Class 1 (30.0-34.9)	29 (14.3)	44 (21.7)	
Class 2 (35.0-39.9)	16 (7.9)	19 (9.4)	
Class 3 (≥ 40.0)	9 (4.4)	10 (4.9)	
Diabetes			0.45
Yes	7 (3.4)	12 (5.9)	
No	85 (41.7)	100 (49.0)	

(continued on following page)

Table 4. Demographic, obstetric factors, and co-morbidities in women with sepsis diagnosis compared to those who met severe sepsis or septic shock criteria (N =204) (continued)

Demographic, delivery, and risk factors	Sepsis n (%)	Severe sepsis or septic shock n (%)	p
Hypertension			0.25
Yes	27 (13.2)	25 (12.3)	
No	65 (31.9)	87 (42.6)	
Preeclampsia			0.78
Yes	8 (3.9)	11 (5.4)	
No	84 (41.2)	101 (49.5)	
Group B streptococcus culture (n = 184)[c]			0.28
Positive	14 (7.6)	13 (7.1)	
Negative	64 (34.8)	93 (50.5)	

χ^2 value for cells with values > 5.
VAVD = vacuum-assisted vaginal delivery.
[a] Fisher's exact test.
[b] Hemoglobin < 11 g/dL or less at time of admission.
[c] n = status documented at time SIRS positive.

women with elevated creatinine who developed severe sepsis or septic shock when compared with those without elevated creatinine levels (p < .05). There was a positive correlation between lactic acid and creatinine levels recorded in the women at the time laboratory tests were drawn following a sepsis diagnosis (p < .05).

The mean lactic acid level for all women was 2.4 ± 1.3 mmol/L. Mean (M) lactic acid values were calculated for antepartum patients (n = 12, M = 2.0, SD = 0.8*)*, postpartum (n = 15, M = 2.0, SD = 1.0), and those with postpartum readmissions (n = 10, M = 1.2, SD = 0.5). A positive correlation was noted for lactic acid levels and cervical dilatation recorded at the time of the diagnosis of sepsis (p < .05).

Lactic acid values were also calculated based on stages of labor, defined as early, less than 6 cm of cervical dilation (n = 35, M = 1.9, SD = 0.9), 6 to 10 cm of dilation (n = 61, M = 2.4, SD = 1.2), and complete dilation (n = 50, M = 3.0, SD = 1.4). Several notes in the clinical record indicated a patient met SIRS criteria while pushing, but there was a decision to delay blood collection until the immediate postdelivery period. A time period for the first 3 hours postdelivery was created in acknowledgment that the time of sepsis was often associated with the time of delivery. The mean lactic acid values for this period resembles that of complete dilation (n = 20, M = 3.1, SD = 1.5).

There were 145 infants born to women who developed intrapartum sepsis. Most (n = 140, 96.6%) had a gestational age greater than 35 weeks. At the study site, infants with a gestational age less than 35 weeks are admitted to the neonatal intensive care unit (NICU). Data related to NICU admission for was available for 141 (97.2%) infants; of these, 27 (19.1%) required a NICU admission for a reason other than gestational age (13.7%, p = .43). One infant, born to a mother who developed septic shock, required whole body cooling.

Table 5. Combinations of obstetric-adjusted SIRS present at time of diagnosis of sepsis (N =204)

Obstetric-adjusted SIRS Present	Frequency n (%)
T + MHR	70 (34.3)
T + FHR	41 (20.1)
T/MHR/FHR	22 (5.5)
T + WBC	18 (8.8)
T/MHR/WBC	17 (8.3)
MHR/FHR	9 (4.4)
T/MHR/WBC/FHR	8 (3.9)
MHR + WBC	6 (2.9)
T/MHR/RR	5 (2.4)
MHR/WBC/FHR	3 (1.5)
T/WBC/FHR	2 (1.0)
RR + FHR	1 (0.5)
T/MHR/RR/FHR	1 (0.5)
WBC + FHR	1 (0.5)

FHR = fetal heart rate tachycardia > 160 bpm for > 10 minutes; MHR = maternal heart rate > 110 bpm; RR = maternal respiratory rate > 24 bpm; T = maternal temperature ≥ 38.0°C; WBC = maternal white blood cell count > 15,000 × 10^9 L.

Neonatal Apgar scores at 1 and 5 minutes of age were compared against the distribution of Apgar scores of all deliveries during the study period. An Apgar score ≤ 6 at 1 and 5 minutes was more likely with intrapartum sepsis, odds ratio 12.1 (95% CI = 7.9-18.6) for the 1-minute Apgar, and 3.1 (95% CI = 1.4-6.8) for the 5-minute Apgar score. Infant Apgar scores ≤ 6 at 1 minute were associated with the presence of funisitis or vasculitis in the placenta when compared to solely the presence of chorioamnionitis $\chi 2$ (1, N = 96) = 4.68, p < .05. No statistical significance was

noted between the unique SIRS combinations and the presence of vasculitis or funisitis in the placenta.

DISCUSSION

There was no established standard of care for identification of possible sepsis in this population at the study site before the implementation of this routine standard screening process. Thus, we could not compare results with any previous process. However, per the SEP-1 criteria, there are established time frames for the administration of antibiotics and a fluid bolus when sepsis is identified. We found that use of routine screening for sepsis using obstetric-adjusted SIRS criteria resulted in timely assessment for end-organ dysfunction and administration of antibiotics. Fluid bolus administration of at least 1 L of fluid was provided to 75% of the women, whereas in the past there was no standard for treatment with an intravenous fluid bolus in this population. We observed few cases of severe morbidity and no maternal deaths related to sepsis.

Strengths of this study include the delivery volume at the study site, the standardized approach used to assess for the presence of sepsis, and the information related to neonates born to women who developed sepsis during labor. Individual chart review ensured the accuracy of diagnoses and an assessment of the completeness of data. Upon review of the administrative data set, only 1 case of severe sepsis was not identified by the presence of SIRS criteria. Although our study did not allow us to directly assess the sensitivity and specificity of our screening criteria, in this population these criteria performed well as a screening tool for sepsis in gravidae.

In our study, there was insufficient information to identify any specific pattern of obstetric-adjusted SIRS criteria that predicted ICU admission. This was in contrast to a prospective study using the Sepsis in Obstetrics Score, which reliably demonstrated a scoring system that identified women at high risk for ICU admission.[22,23] The Sepsis in Obstetrics Score included vital signs (temperature, systolic blood pressure, heart rate, respiratory rate, blood oxygen saturation), and lactic acid, WBC, and immature neutrophils.[22]

The 2017 Society of Obstetric Medicine Australia and New Zealand guidelines outline use of an obstetrically modified quick Sequential Organ Failure Assessment score called omqSOFA.[8] The omqSOFA uses the concept of a quick assessment, similar to the qSOFA established in Sepsis-3.[5] There are 3 parameters in the omqSOFA assessment that earn a score of 1; respiratory rate > 25 breaths per minute, systolic blood pressure < 90 mmHg, and altered mentation.[8] A score meeting 2 or more may then require an assessment for sepsis.[8] This guideline was not published before the beginning of our initiative and was not considered for adoption at our site. However, when the score was calculated as part of data analysis, no women in our population achieved an omqSOFA score of 2 or more.

The observed incidence of sepsis in this study, 4%, is consistent with the reported incidence of chorioamnionitis of between 3% and 5%.[24] Chorioamnionitis was the predominant source of infection in the study population (62.7%). Before the start of this initiative, the clinical suspicion of chorioamnionitis would trigger the bedside nurse to notify the obstetric provider of the abnormal findings, which subsequently led to a very similar treatment workflow. Although our criteria may not be specific for sepsis-related morbidity, it performs well as an initial screen as a good screening tool may sacrifice specificity to achieve a high sensitivity.

Chorioamnionitis may first present with fetal response, identified by fetal tachycardia. As such, we included fetal tachycardia as a screening criterion, consistent with that used by Shields et al.[15] and the National Sepsis Programme.[18] The use of fetal tachycardia as an obstetric-adjusted SIRS criterion resulted in the identification of women who would not otherwise have been assessed for end-organ dysfunction, as roughly 1/3 were found to have significantly elevated lactate levels. Elevation of lactic acid is associated with maternal morbidity. The exclusion of fetal tachycardia in our screening criteria would have resulted in a missed opportunity for early recognition and timely treatment for these women. Although other authors have not incorporated fetal tachycardia in their screening criteria, we feel that it is an important predictor of morbidity and warrants consideration.

The use of lactic acid as a marker of severity of sepsis has not been well-studied in the obstetric population. Although research is limited, the progress of labor may affect lactic acid level in the absence of concerns of sepsis or infection.[25,26] We observed a correlation, with higher values in active labor and the second stage of labor. These findings may reflect a tendency for lactic acid levels to be higher during active labor, consistent with Bauer et al.[25] At the study site, most obstetric patients with lactic acid values > 3.9 are managed in labor and delivery and not transferred to the ICU. This limits the ability to compare ICU admissions as a marker of severity of illness. Further research on the relationship between labor and lactic acid is needed to better improve the recognition and management of sepsis in the obstetric population. [25]

Our data demonstrated a correlation between elevated lactate levels and the likelihood of depressed Apgar scores. The Neonatal Resuscitation Program guidelines[27] recommend that there be 2 Neonatal Resuscitation Program-trained individuals assigned to care for the neonate at the time of delivery when the mother has chorioamnionitis. Our findings suggest the presence of a full complement of pediatric providers at the delivery of a woman who, while in labor, develops sepsis from any source.

The results of this study may not be generalizable to other centers as the sample was limited to 1 site, where most women experience care as part of an integrated health system. Not all who met the criteria for sepsis may have been identified because of limitations of the methods selected. However, administrative data failed to show missed cases. Urine output data were missing in 104 of 181 (57.4%) of the records. These missing data may have resulted in the lack of identification of cases of severe sepsis through data review.

Challenges related to maintenance of routine screening at the study site include the lack of a sepsis-specific documentation flowsheet in the EMR. This type of flowsheet would act as a prompt for the nurse to document the sepsis screen results. Although all newly hired clinicians are instructed in the use of the Maternal Sepsis Screening Pathway, there is not a routine process in place to ensure that new and experienced staff are continuing to routinely screen for sepsis and treat patients per the maternal sepsis pathway. Factors that contribute to the development of chorioamnionitis, such as frequent vaginal examinations, were not specifically addressed in the design of this study. Future quality improvement work related to sepsis in this population would benefit from the establishment of safety guidelines limiting practices which may contribute to the development of chorioamnionitis.

We suspect that inclusion of fetal tachycardia, at least as we have defined it, to be overly sensitive. Although we feel we missed no cases of sepsis, many women with chorioamnionitis underwent a complete sepsis workup that may be unwarranted. Further research is needed to better understand how the fetal response to maternal infection relates to significant morbidity.

Difficulties in implementation of routine screening for sepsis in the obstetric population include creating a shared mental model about which clinical symptoms require a timely assessment for sepsis, which laboratory tests provide relevant information, the relation of lactic acid results to severity of sepsis, and the need for intravenous fluid administration. Some of these challenges were evident in this study as inconsistent ordering of certain laboratory tests, fluid boluses, and documentation of urine output by nurses. Sharing this information with the clinical teams, and monitoring for improvement in these areas, are some steps that could improve future performance of this initiative.

CONCLUSION

Adult sepsis screening tools were not designed to adequately assess for sepsis in the maternal population. The normal physiologic changes of pregnancy necessitate the adoption of SIRS criteria that are specific to the obstetric population. The criteria proposed here accurately identified all but 1 case of sepsis and were easily implemented. Our findings support the practice of routine, ongoing screening with obstetric-adjusted SIRS criteria, including FHR tachycardia. Standardized, ongoing assessment for sepsis, paired with timely administration of antibiotics and fluid resuscitation, may reduce maternal morbidity by prompting early identification and treatment. Routine measurement and documentation of urine output is critically important to aid in the assessment for sepsis. Using the criteria we have proposed, we have better defined sepsis characteristics in the obstetric population. However, a better understanding of the role of lactic acid levels and fetal tachycardia in the intrapartum population are still needed to better understand obstetric sepsis. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

Acknowledgments

The authors express their sincere gratitude to Dr. Melissa Bauer and Dr. Marla Seacrist for their feedback on a draft of this manuscript.

Authors' Contributions

Holly Champagne, DNP, RN, participated in project design, data abstraction and analysis, and drafting and submission of the final manuscript. Matthew Garabedian, MD, participated in study design, data analysis, and drafting of the final manuscript.

How to Cite this Article

Champagne HA, Garabedian MJ. Routine screening for sepsis in an obstetric population: Evaluation of an improvement project. Perm J 2020;24:19.232. DOI: https://doi.org/10.7812/TPP/19.232

References

1. Centers for Disease Control and Prevention (US). Pregnancy mortality surveillance system. Accessed November 2, 2019. https://www.cdc.gov/reproductivehealth/maternalinfanthealth/PMSS.html.
2. Bauer ME, Bateman BT, Bauer ST, Shanks AM, Mhyre JM. Maternal sepsis mortality and morbidity during hospitalization for delivery: temporal trends and independent associations for severe sepsis. Anesth Analg 2013 Oct;117(4):944-50. DOI: https://doi.org/10.1213/ANE.0b013e3182a009c3
3. Levy MM, Dellinger RP, Townsend WT, Linde-Zwirble JC, Bion J, Schorr C, et al. The surviving sepsis campaign: results of an international guideline-based performance improvement program targeting severe sepsis. Crit Care Med 2010 Feb;36(2):222-31. DOI: https://doi.org/10.1007/s00134-009-1738-3
4. MacDorman MF, Declerq E, Cabral H, Morton, C. Recent increases in the U S. maternal mortality rate: disentangling trends from measurement issues. Obstet Gynecol 2016 Sep; 128(3):447-55. DOI: https://doi.org/10.1097/AOG.0000000000001556
5. Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M, et al. The Third International Consensus definitions for sepsis and septic shock (Sepsis-3). JAMA 2016 Aug;315(8):201-10. DOI: https://doi.org/10.1001/jama.2016.0287
6. Bauer ME, Housey M, Bauer ST, Behrmann S, Chau A, Clancy et al. Risk factors, etiologies, and screening tools for sepsis in pregnant women: a multi-center case-control study. Anesth Analg 2019 Dec;129:1613-20. DOI: https://doi.org/10.1213/ANE.0000000000003709 Published ahead of print
7. Bonet M, Nogueira Pileggi V, Rijken MJ, Coomarasamy A, Lissauer D, Souza JP, Gülmezoglu AM. Towards a consensus definition of maternal sepsis: results of a systematic review and expert consultation. Reprod Health 2017 May; 14(1):1-13. DOI: https://doi.org/10.1186/s12978-017-0321-6
8. Bowyer L, Robinson HL, Barrett H, Crozier TM, Giles M, Idel I, et al. SOMANZ guidelines for the investigation and management sepsis in pregnancy. Aust N Z J Obstet Gynaecol 2017 Oct;57(5):540-51. DOI: https://doi.org/10.1111/ajo.12646
9. The Joint Commission. Specifications manual for national hospital inpatient quality measures. Accessed November 2, 2019. https://www.jointcommission.org /assets/1/6/HIQR_Release_Notes_5_5.pdf.
10. Bone RC, Balk RA, Cerra RP, Dellinger AM, Knaus, WA. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. The ACCP/SCCM Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine. Chest 1992 Jun; 101(6):1644-55. DOI: https://doi.org/10.1378/chest.101.6.1644

11. Albright CM, Mehta ND, Rouse DJ, Hughes BL. Sepsis in pregnancy: identification and management. J Perinat Neonatal Nurs 2016 Apr-Jun;30(2):95-105. DOI: https://doi.org/10.1097/JPN.0000000000000178.
12. Albright CM, Ali TN, Lopes V, Rouse DJ, Anderson BL. Lactic acid measurement to identify risk of morbidity from sepsis in pregnancy. Am J Perinatol 2015 Apr;32(5):481-86. DOI: https://doi.org/10.1055/s-0034-1395477
13. Barton JR, Sibai BM. Ask the experts: severe sepsis and septic shock in pregnancy. Obstet Gynecol 2012;120:689-706. Accessed November 15, 2020. https://journals.lww.com/greenjournal/pages/collectiondetails.aspx?TopicalCollectionId=5
14. Bauer ME, Bauer ST, Rajala B, MacEachern MP, Polley LS, Childers D, et al. Maternal physiologic parameters in relationship to systemic inflammatory response syndrome criteria: a systemic review and meta-analysis. Obstet Gynecol 2014 Sep;124(3):535-41. DOI: https://doi.org/10.1097/AOG.0000000000000423
15. Shields LE, Wiesner S, Klein C, Pelletreau B, Hedriana HL. Use of maternal early warning trigger tool reduces maternal morbidity. Am J Obstet Gynecol 2016 Apr;214(4):572.e1-e6. DOI: https://doi.org/10.1016/j.ajog.2016.01.154
16. Committee on Obstetric Practice. Committee opinion no. 712: intrapartum management of intraamniotic infection. Obstet Gynecol 2017 Aug;130(2):e95-101. DOI: https://doi.org/10.1097/AOG.0000000000002236.
17. Faksh A, Martin S. Maternal sepsis: current approaches to recognition and clinical management. Curr Womens Health Rev 2016 Apr;12(1):20-38. DOI: https://doi.org/10.2174/1573404812666160727121235
18. National Sepsis Programme (IE). National sepsis outcome report. 2016. Accessed November 2, 2019. https://www.hse.ie/eng/services/publications/clinical-strategy-and-programmes/national-sepsis-report-2016.pdf.
19. Bauer ME, Lorenz RP, Bauer, ST, Rao K, Anderson FWJ. Maternal deaths due to sepsis in the state of Michigan, 1999-2006. Obstet Gynecol 2015 Oct;126(4):747-25. DOI: https://doi.org/10.1097/AOG.0000000000001028
20. Olvera L, Dutra D. Early recognition and management of maternal sepsis. Nurs Womens Health 2016 Apr-May;20(2):184-96. DOI: https://doi.org/10.1016/j.nwh.2016.02.003
21. Rhodes A, Evans LE, Alhazzani W, Levy MM, Antonelli M, Ferrer, M, et al. Surviving sepsis campaign: international guidelines for management of sepsis and septic shock:2016. Intensive Care Med 2017 Mar;43(3):304-77. DOI: https://doi.org/10.1007/s00134-017-4683-6
22. Albright CM, Ali TN, Lopes V, Rouse DJ, Anderson BL. The sepsis in obstetrics score: a model to identify risk of morbidity from sepsis in pregnancy. Am J Obstet Gynecol 2014 Jul;211(1):e1-8. DOI: https://doi.org/10.1016/j.ajog.2014.03.010
23. Albright CM, Has P, Rouse DJ, Hughes BL. Internal validation of the Sepsis in Obstetrics score to identify risk of morbidity from sepsis in pregnancy. Obstet Gynecol 2017 Oct;130(4):747-55. DOI: https://doi.org/10.1097/AOG.0000000000002260
24. Kim CJ, Romero R, Chaemsaithong P, Chaiyasit N, Yoon BH, Kim. YM. Acute chorioamnionitis and funisitis: definition, pathologic features, and clinical significance. Am J Obstet Gynecol 2015 Oct;213(4 Suppl):S29-52. DOI: https://doi.org/10.1016/j.ajog.2015.08.040
25. Bauer ME, Balistreri M, MacEachern M, Cassidy R, Schoenfeld R, Sankar K, et al. Normal range for maternal lactic acid during pregnancy and labor: a systematic review and meta-analysis of observational studies. Am J Perinatol 2019 Jul; 36(9) 898-906. DOI: https://doi.org/10.1055/s-0038-1675243
26. Nordström L, Achanna S, Naka K, Arulkumaran S. Fetal and maternal lactate increase during active second stage of labour. Br J Obstet Gynaecol 2001 Mar;108(3):263-68. DOI: https://doi.org/10.1111/j.1471-0528.2001.00034.x
27. Weiner GM, Zaichkin J, Kattwindel J., editors. Textbook of neonatal resuscitation, 7th ed. Elk Grove Village, IL: American Academy of Pediatrics; American Heart Association, 2016.