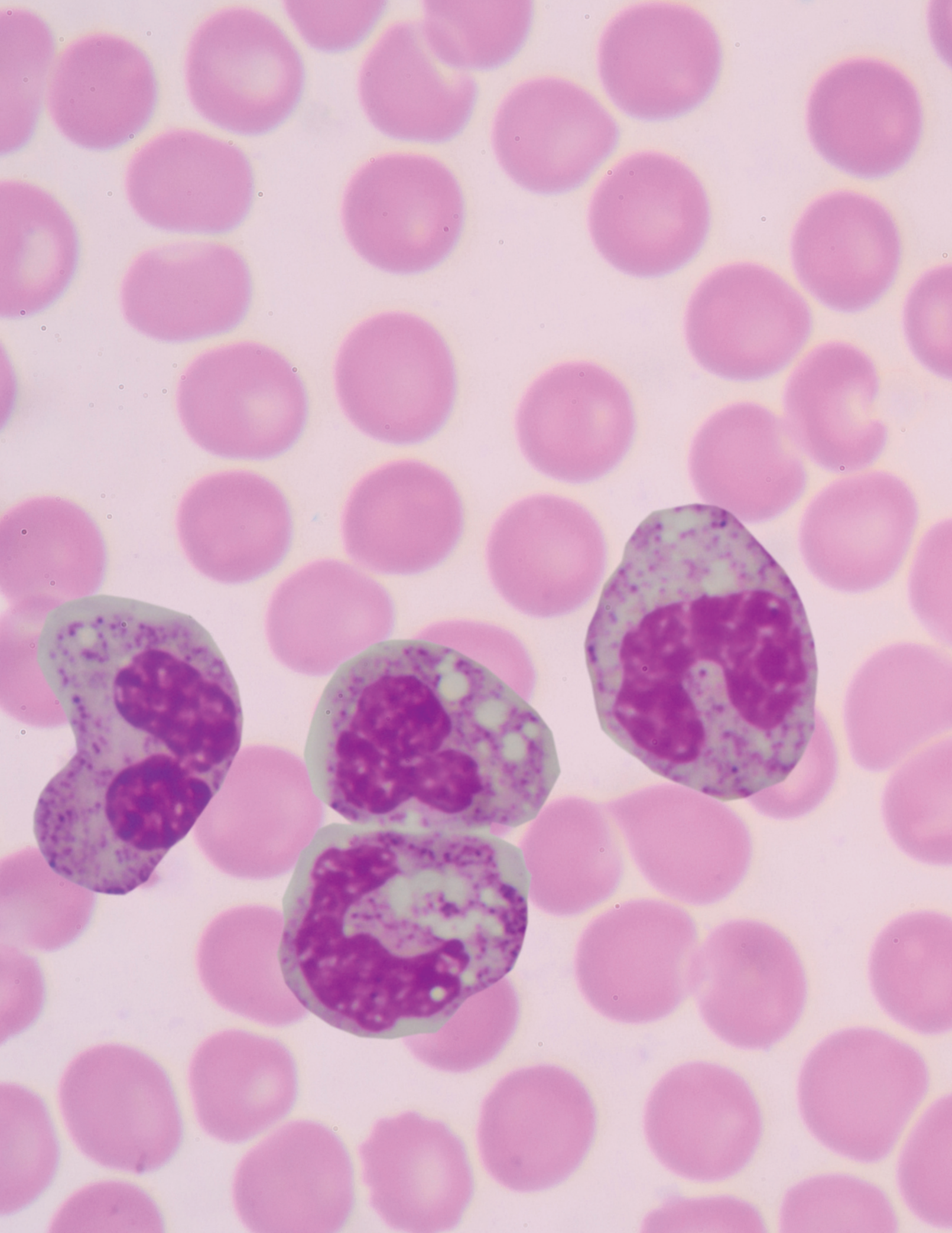
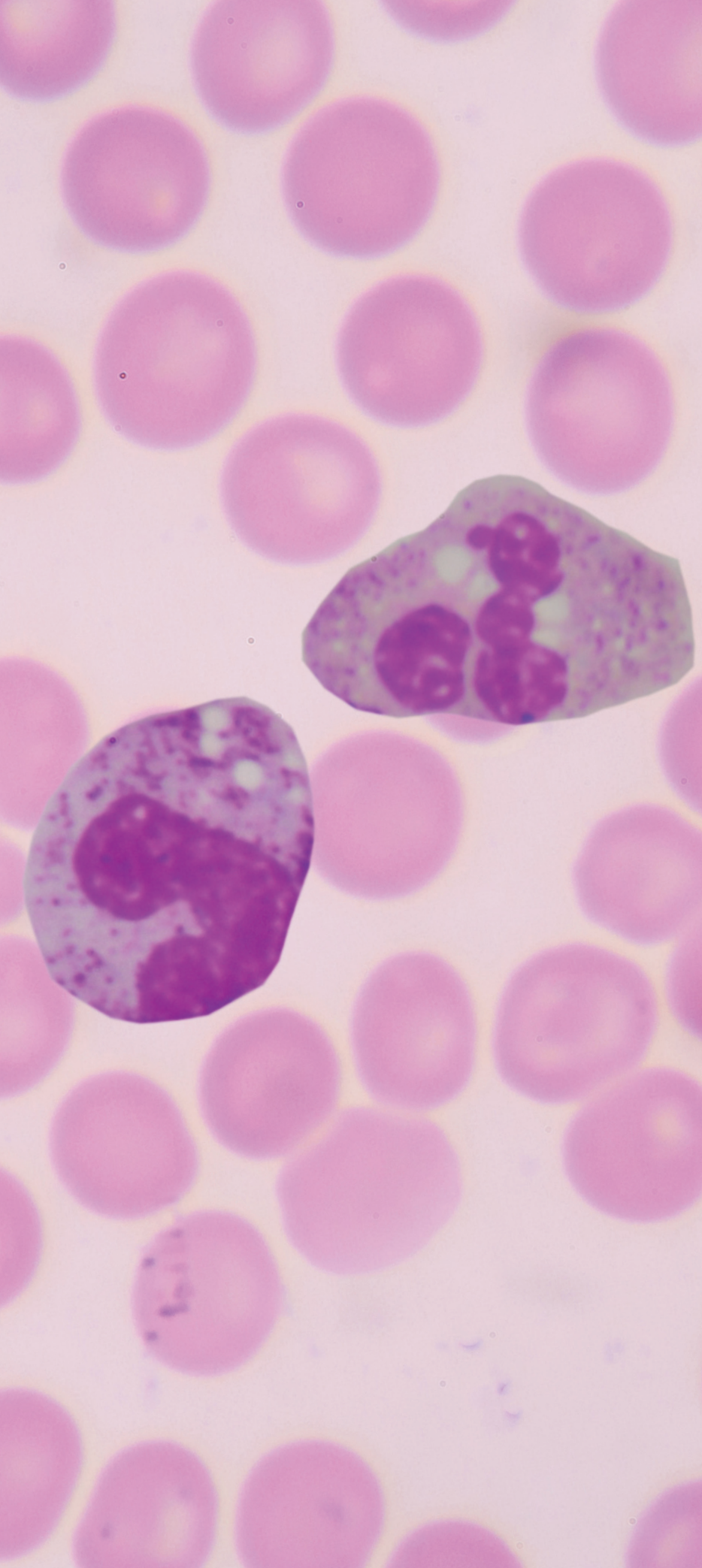






Early Recognition and Management of Maternal Sepsis

Lori Olvera
Danette Dutra

Objectives

Upon completion of this activity, the learner will be able to:

1. Describe primary sites of maternal infection.
2. Explain how physiologic changes of pregnancy can mimic signs of sepsis.
3. Describe the premise and results of a project studying the effect of a physician order set and interprofessional education on early recognition and management of maternal sepsis.

Continuing Nursing Education (CNE) Credit

A total of 1.25 contact hours may be earned as CNE credit for reading “Early Recognition and Management of Maternal Sepsis” and for completing an online posttest and participant feedback form.

To take the test and complete the participant feedback form, please visit <http://www.awhonn.org/?OnlineLearningCenter>. Certificates of completion will be issued on receipt of the completed participant feedback form and processing fees.

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INTRODUCTION

Hearing a “Code Blue” in the perinatal department is every nurse’s nightmare. The loss of a woman and/or her newborn to a preventable condition such as sepsis is unforgettable. Maternal sepsis is the leading cause of preventable maternal death, accounting for 15% of all maternal deaths worldwide (Acosta & Knight, 2013; Bamfo, 2013). Failure to recognize early warning signs of sepsis and a lack of guidelines to manage treatment of sepsis contribute to these preventable deaths. Fortunately, septic shock is rare in pregnancy, affecting only 0.002% to 0.010% of all births (Snyder, Barton, Habli, & Sibai, 2013). However, sepsis remains an important contributor to the maternal mortality.

Protocols for early recognition and management of maternal sepsis are needed, because the progression from onset of systemic inflammatory response syndrome (SIRS) to severe sepsis occurs very rapidly (Acosta et al., 2014; see Box 1 for a link to a video on maternal sepsis). Pregnant women are more vulnerable to infection and susceptible to serious complications than nongravid women (Joseph, Sinha, Paech, & Walters, 2009). All obstetric health care professionals should have regular training and education on early recognition of sepsis, signs and symptoms, and the need for prompt assessment and treatment to prevent the rapid progression of sepsis to septic shock (Cantwell et al., 2011).

IMPLEMENTING EVIDENCE-BASED PRACTICE CHANGE

The purpose of our project was to explore compliance with early goal-directed therapy before, during, and after the implementation of a standardized physician order set and interprofessional education in the perinatal setting. SIRS criteria were adjusted to account for the physiologic effects of pregnancy.

SEPSIS GUIDELINES

The Surviving Sepsis Campaign, an international initiative to reduce mortality by sepsis, developed guidelines to assist clinicians

Abstract: Although septic shock is rare in pregnancy, it is an important contributor to maternal mortality. A woman in the perinatal period can appear deceptively well before rapidly deteriorating to septic shock. We evaluated compliance with early goal-directed therapy before, during, and after the implementation of a standardized physician order set and interprofessional education. A retrospective study included 97 women with positive screening results for sepsis from April 2014 to January 2015. When comparing preintervention and postintervention results in women with sepsis, statistical significance was achieved for blood lactate level testing ($p = .029$), administering a broad-spectrum antibiotic ($p = .006$), repeat lactate level testing ($p = .034$), and administering a broad-spectrum antibiotic in women with severe sepsis and septic shock ($p = .010$). Education and a sepsis protocol using a multidisciplinary approach improves compliance with sepsis bundles, which are a group of interventions that, when used together, are intended to improve health outcomes. <http://dx.doi.org/10.1016/j.nwh.2016.02.003>

Keywords: maternal sepsis | quality improvement project | retrospective study | septic shock | standardized physician order set

BOX 1 MATERNAL SEPSIS VIDEO

This video was created to motivate health care professionals caring for perinatal patients to implement interprofessional education and protocols for early recognition and management of maternal sepsis.

FIND THE VIDEO HERE:

<http://bcove.me/k8cl9d8j>



in recognizing and treating sepsis (Nguyen, Schiavoni, Scott, & Tanios, 2012). The Surviving Sepsis Campaign introduced interventions that, when grouped together (i.e., into *bundles*), improve patient outcomes. These interventions were derived from evidence-based practice and must be implemented as a group rather than individually to achieve the best patient outcomes (see Box 2). The Surviving Sepsis Campaign recommends that hospitals develop customized sepsis protocols using these care bundles to achieve the 25% expected reduction of mortality.

SIRS CRITERIA

The Surviving Sepsis Campaign was not widely accepted among obstetric providers, generally because criteria for SIRS were not defined for pregnant women. It was difficult to apply these criteria to pregnant women because the physiologic changes of pregnancy mimic signs of sepsis. White blood cell counts increase throughout pregnancy (Guinn, 2011) and can be greater than

20,000 in a pregnant woman without evidence of infection. Heart rate increases progressively during pregnancy by 10 to 20 beats per minute. This change in heart rate represents a 20% to 25% increase over the baseline rate (Sanghavi & Rutherford, 2014).

Pregnant women typically exhibit an increase in respiratory depth, although respiratory rate remains unchanged, because of stimulation of the respiratory center in the brain secondary to increased progesterone during pregnancy (Yeomans & Gilstrap, 2005). Respiratory rate and heart rate increase during the second stage of labor with pushing efforts; thus, it is dif-

Maternal sepsis is the leading cause of preventable maternal death, accounting for 15% of all maternal deaths worldwide

ficult to use SIRS criteria as a valid screening tool during this time (Guinn, 2011).

Changes in respiratory physiology, including an increase in tidal volume and a reduction of residual volume and functional residual capacity, lead to an increase in respiratory rate and minute ventilation, resulting in respiratory alkalosis with a compensatory metabolic acidosis. A pregnant woman has a diminished ability to compensate for metabolic acidosis when her condition is complicated by a severe infection (Joseph et al., 2009). Therefore, pregnant women may appear deceptively well before experiencing vascular collapse secondary to severe sepsis and/or septic shock.

Cardiac output increases 50% during birth, with large fluid shifts and significant blood loss (Guinn, 2011). Common interventions during labor and birth, such as administration of intravenous fluids and use of epidural anesthesia, blur the clinical picture for early recognition of sepsis. Increased maternal temperature in labor might be attributed to epidural anesthesia and thus delay a diagnosis of sepsis in laboring women. Gonen, Korobochka, Degani, and Gaitini (2000) found that 11.8% of women who received epidural anesthesia ($n = 406$) developed an intrapartum fever greater than 37.8°C.

The SIRS criteria were not developed with maternal-specific parameters for sepsis in the pregnant population. In a study by Waterstone, Bewley, and Wolfe (2001), the standard definition of sepsis included modified SIRS criteria incorporating the physiologic changes of pregnancy. This definition was used to estimate incidence and predictors of severe obstetric morbidity. This was the first attempt to adjust SIRS criteria for the pregnant population and develop reproducible definitions defining severe sepsis. Use of adjusted SIRS criteria in perinatal women was replicated in a study by Acosta et al. (2014).

INCREASED SUSCEPTIBILITY TO INFECTION

Physiologic changes in a pregnant woman's immune system allow tolerance to paternally derived fetal antigens (Lapinsky, 2013). The maternal immune response in pregnancy is decreased to protect the immunologically distinct fetus. As a result, a pregnant woman has a predisposition for developing severe bacterial, fungal, or viral infections. A woman having a cesarean birth is at greater risk of developing infection at the surgical site and endometrium. In addition, a pregnant woman is at greater risk for developing acute respiratory distress syndrome secondary to a suppressed immune system.

Pregnant women may appear deceptively well before experiencing vascular collapse secondary to severe sepsis and/or septic shock

Common infections during pregnancy, especially if untreated, may lead to sepsis. Primary sites of infection in pregnancy are the urinary tract (pyelonephritis), pelvic structures (chorioamnionitis and endometritis), surgical wounds (cesarean birth), and breasts (mastitis; Joseph et al., 2009). During pregnancy, the smooth muscle relaxation and obstruction of the ureters result in dilatation of the renal collecting system. This leads to urinary stasis and asymptomatic bacteriuria, a precursor for pyelonephritis. Chorioamnionitis is a common obstetric complication occurring in approximately 1% to 5% of term births and 25% of preterm births (Black, Hinson, & Duff, 2012). Chorioamnionitis, a histopathologic finding of inflammation of the amnion and/or the chorion, is a result of bacterial infection of the amniotic fluid (Fahey, 2008). The most common route of intrauterine infection is ascending bacteria from the lower genital tract. Because intra-amniotic infection and pyelonephritis

BOX 2 ITEMS TO BE COMPLETED WITHIN 3 HOURS OF TIME OF PRESENTATION

1. Measure lactate level
2. Obtain blood culture samples before administration of antibiotics
3. Administer broad-spectrum antibiotic
4. Administer 30 ml/kg crystalloid intravenous solution for hypotension or for lactate level ≥ 4 mmol/L

Source: Surviving Sepsis Campaign (2012).

are common causes of obstetric sepsis and are difficult to recognize because of the physiology of pregnancy, protocols and guidelines must be developed for early recognition and treatment of severe sepsis and/or septic shock.

OUR PROJECT

Design

Our project measured bundle compliance data using retrospective health record review in a real-time quality improvement process. We measured staff compliance to the care bundles before, during, and after the implementation of a perinatal sepsis physician order set. Education for obstetric nurses, rapid response team nurses, and obstetricians was provided throughout the project. The Iowa Model, a framework for decision-making and an algorithm for organizing the step-by-step process of a change project, is useful for implementing evidence-based practice at an organization level (Melnik & Fineout-Overholt, 2011). The Iowa Model supports the use of interdisciplinary teams to implement evidence-based practice in the delivery of health care and was used to implement this project.

Setting

Our setting was a large community center in northern California. This hospital is part of an integrated health care system and provides Level 3 maternity services and Level 4 neonatal services, with approximately 5,500 births per year.

Population and Sample

The population was a convenience sample consisting of 350 nurses and 50 physicians who work in the Labor & Delivery, High-Risk Maternity, and Maternal–Newborn units.

Using a systematic health record review, we measured compliance with the indicators of early goal-directed therapy before, during, and after implementation of a perinatal sepsis physician order set and education for nurses and physicians. Inclusion criteria were women with positive sepsis screening results between April 2014 and January 2015. Exclusion criteria included women with pregnancies of less than 20 weeks gestation or women not meeting sepsis definition criteria. We reviewed 99 health records in which 97 women met criteria for the study. Institutional review board approval was obtained from the hospital in which the study was conducted and from California State University, Fresno. The author from California State University, Fresno, made every reasonable effort to limit protected health information to the minimum necessary to accomplish the intended purpose of use, disclosure, or request.

Maternal Adjusted Parameters for Sepsis Screening

To accurately screen for sepsis in women in the perinatal period, we adjusted the SIRS criteria for use in pregnant women. For a pregnant woman, meeting the original SIRS criteria could be a sign of the changing biochemistry associated with labor and birth and a normal physiologic finding, or it could be a

FIGURE 1 SEPSIS SCREENING TOOL

SEPSIS SCREEN
To be completed every shift and PRN.

Date/Time of Form Completion
New Date/Time of Form Completion
7/27/2011 08:53

A. Infection
☒ Yes, Patient is on antibiotics (not prophylaxis).
☒ Yes, Patient has an infection or suspicion of infection.
☐ IF NEITHER, CHECK HERE AND STOP.
IF NEITHER, STOP HERE!

B. SIRS (Systemic Inflammatory Response Syndrome)
 Patient has 2 or more of the following SIRS criteria:
☐ Blood glucose ≥ 120 mg/dl in absence of diabetes
☒ HR > 100 BPM
☐ New mental status change/GCS change
☐ RR > 20 breaths/min.
☐ T > 38.3 (101) or < 36 (96.8)
☐ WBC $> 12,000$, $< 4,000$, or > 10 percent immature neutrophils.
☐ If in active labor or PP, WBC $> 20,000$, < 4000 , or > 5 percent immature neutrophils.
If A & B are met, screen is positive for sepsis.
Sepsis Screen:
☒ Negative
If sepsis screen positive for sepsis: Initiate Adult RRT, rescreen Q 6 hrs, and suggest Q 6 hr lactate x4.
Initiate RRT - time: M / d / yyyy H :mm

C. ACUTE Organ Dysfunction
 Patient meets one or more of the following criteria:
☐ SBP < 90 mmHG or MAP < 65 mmHG with HR ≥ 100 .
☐ SBP decreased > 40 mmHG from baseline.
☐ New (or increased) oxygen requirement to maintain SpO₂ > 90 .
☐ Urine Output ≤ 20 ml/hr, or Creatinine ≥ 2 mg/dl.
☐ Bilirubin > 2 mg/dl.
☐ Platelet count $< 100,000$.
☐ Coagulopathy (INR > 1.5 or aPTT > 60 secs).
☐ Lactate ≥ 2 mmol/L.
If all criteria met for A, B & C, screen is positive for SEVERE sepsis.
New Severe Sepsis Screen
☒ Negative
☐ New positive screen for severe sepsis/ RRT called sepsis alert.
MD notified: M / d / yyyy H :mm
☐ Transferred to ICU ☐ Transferred to Higher Level of Care.

aPTT = activated partial thromboplastin time; GCS = Glasgow Coma Scale; HR = heart rate; ICU = intensive care unit; INR = international normalized ratio; MAP = mean arterial pressure; PP = postpartum; RR = respiratory rate; RRT = rapid response team (nurse); SBP = systolic blood pressure; SpO₂ = oxygen saturation; T = temperature; WBC = white blood cell count.

clinical sign of a severe infection. We adjusted the criteria to include maternal heart rate of 100 beats per minute and white blood cell counts of 20,000 (Waterstone et al., 2001; Acosta et al., 2014). Our interdisciplinary team adjusted the white blood cell count to greater than 20,000 for laboring women and greater than 12,000 for nonlaboring pregnant women. See Figure 1 for the sepsis screening tool.

Interventions

We recruited two physician champions to support the project and provide education to other physicians within the service line. Physician buy-in was crucial for the success of the project. Poster board presentations of sepsis education and evidence-based literature were placed in the physician break room for review. Education for physicians was implemented first, because physician support and knowledge of maternal sepsis were important to avoid resistance to the new protocol.

We recruited nurse champions to provide one-on-one education of nurses regarding the new physician order set. They reviewed sepsis screening, the standardized physician order set, and evidence-based practice for the recognition and management of severe sepsis and/or septic shock. Poster presentations, case studies, and evidence-based literature were displayed for nurses to review. A single-sheet quick reference guide was provided to all staff (see Figure 2). We conducted formal 2-hour educational sessions to increase awareness of the importance of early recognition and management of maternal sepsis.

We developed a computer-based education program for all nurses to test their knowledge regarding maternal sepsis and the application of the care bundles. Completion of the computer-based learning module and a posttest was mandatory for all nurses caring for perinatal women.

The physician order set (see Figure 3) supported the bundles of care recommended by the Surviving Sepsis Campaign (2012). Physician orders included interventions to be completed by the registered nurse, and other interventions were recommendations to provide point-of-care decision-making capability.

Pharmacists were important stakeholders and champions for rollout of this quality and safety initiative; they functioned as stewards to antimicrobial safety. Antimicrobial stewardship improves health care, reduces rates of resistance, and prolongs the longevity of the limited number of antimicrobial agents available to treat infections (American Society of Health-System Pharmacists, 2010).

Engaging frontline leaders in the implementation of the project was crucial to its success. Perinatal clinical nurse specialists and members of the perinatal management team were important stakeholders and mentors for the successful rollout of this project. These stakeholders were crucial to aligning the goals of the project with the goals of the organization. It is important to ensure that the goals of innovation advance the interest of the organization (Porter-O'Grady & Malloch, 2011).

Outcome Measures

Health records of women with positive screening results for sepsis were reviewed from April 2014 to January 2015 to determine if educational interventions increased sepsis bundle compliance. The education began in August 2014. Data were collected for two time periods: (a) April 2014 through July 2014 (*preintervention*) and (b) August 2014 through January 2015 (*postintervention*). Data were collected for three parameters: *sepsis criteria*, *severe sepsis*, and *septic shock*. For women meeting sepsis criteria, four bundle compliance indicators were measured. The first three bundle compliance indicators were used to measure total bundle compliance. The administration of intravenous fluid boluses was measured but not required to meet the bundle compliance for sepsis.

To measure the difference in bundle compliance preintervention and postintervention, data from the first time period were compared with data from the second time period. Data from the initial infection were measured separately to determine the source of infection. Frequency and percentage tables were used to analyze the differences.

RESULTS

Table 1 displays the frequency of sepsis, severe sepsis, and septic shock from April 2014 through January 2015, during which 99 women met the sepsis criteria. Of the 99 women with positive

results from a sepsis screening performed by a nurse, 97 (98%) were confirmed to be sepsis positive by a rapid response team nurse. For women meeting the sepsis criteria, 48.5% ($n = 47$) progressed to severe sepsis, and 7.2% ($n = 7$) progressed to septic shock.

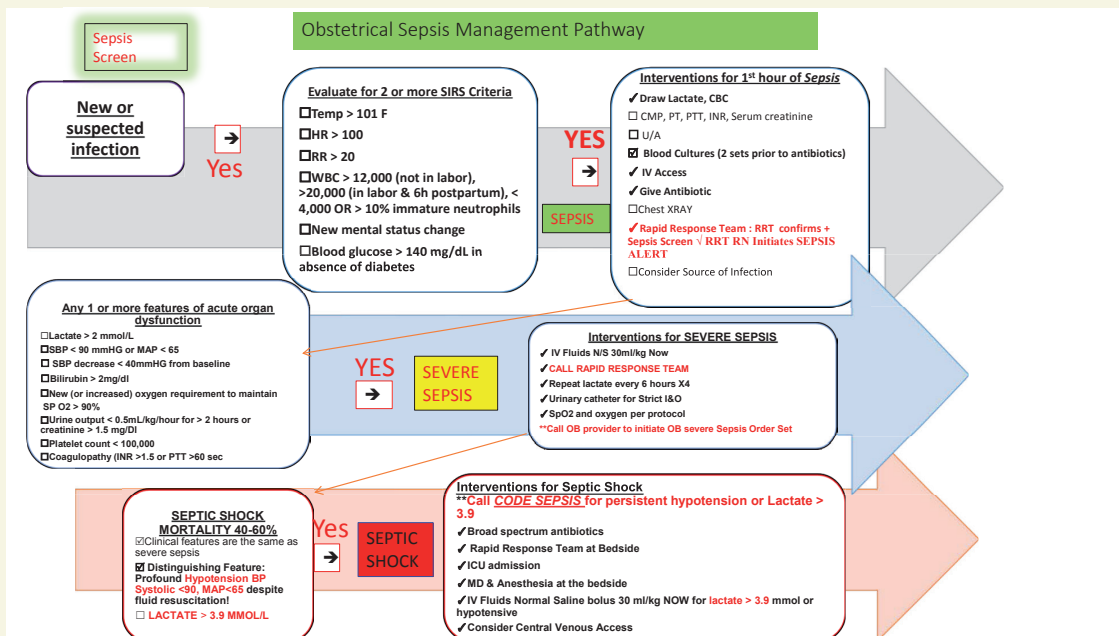
Because common infections can lead to sepsis and the type of antibiotic used is dependent on the type of infection, it was important to look at the source of infection. Table 2 displays the number of women diagnosed with common infections of pregnancy.

Table 3 displays bundle compliance for women with sepsis, severe sepsis, and septic shock preintervention and postintervention. The administration of a 30-ml/kg bolus of crystalloid intravenous solution is recommended only for women with severe sepsis and/or septic shock. The frequency of intravenous bolus administration was measured, but this was not required for women meeting sepsis criteria.

DATA ANALYSIS

A chi-square test was used to quantify the relationship between preintervention and postintervention bundle compliance. Assumptions of the cross tabulations were met to perform the chi-square test. A p value less than .05 was considered significant. To meet the assumptions of the cross tabulations, results for severe sepsis and septic shock were collapsed into one group.

FIGURE 2 QUICK REFERENCE GUIDE



BP = blood pressure; CBC = complete blood count; CMP = comprehensive metabolic panel; h = hours; HR = heart rate; I&O = intake and output; ICU = intensive care unit; INR = international normalized ratio; IV = intravenous; MAP = mean arterial pressure; MD = physician; OB = obstetric; PT = prothrombin time; PTT = partial prothrombin time; RN = registered nurse; RR = respiratory rate; RRT = rapid response team (nurse); SP or SBP = systolic blood pressure; SIRS = systemic inflammatory response syndrome; temp = temperature; U/A = urinalysis; WBC = white blood cell count.

FIGURE 3 SAMPLE PHYSICIAN ORDER SET

+	+
☐ STAT MEDICATION	☐ SCANNED TO PHARMACY
Date: _____ Time: _____	
Allergies: _____	
Diagnosis: _____	
<i>If none selected Notify MD immediately. Ensure blood cultures are obtained prior to antibiotic initiation.</i>	
SYSTEMIC INFLAMMATORY RESPONSE CRITERIA	
If 2 or more of following SIRS criteria are present with documented or suspected infection - Temp greater than 38.3°C (101°F) or < 36°C (96.8°F) - HR greater than 100 bpm - RR greater than 20 breaths/minute - WBC greater than 20,000 (in labor), greater than 12,000 (not in labor), < 4,000 OR greater than 10% immature neutrophils - New mental status change - Blood glucose $\geq$ 140 mg/dl in absence of diabetes	
INTERVENTIONS FOR SEPSIS	
☐ Initiate peripheral IV _____ #16 gauge _____ #18 gauge using 1% lidocaine per protocol. ☐ IV _____ at _____ ml/hr ☒ Initiate Rapid Response Team ☒ Vital Signs (BP, P, R) every 30 min X 4, every 1 hour X 4, then every shift ☒ Temperature every 2 hours ☒ O2 per oxygen therapy protocol - keep O2 saturation greater than or equal to 92% ☒ Initiate antibiotics within 60 minutes of "identified sepsis" considering source of infection	
LABS AND RADIOLOGY STUDIES	
☒ Lactate STAT and every 6 hours X 4 ☒ CBC ☐ Blood Cultures X 2 (prior to administration of antibiotics) ☐ Comprehensive Metabolic Panel ☐ Protime ☐ Partial Thromboplastin Time ☐ UA and culture if indicated ☐ Arterial Blood Gas (for respiratory symptoms) ☐ Chest X-ray (PA & LAT) Indication: _____ ☐ Serum Creatinine	
ACUTE ORGAN DYSFUNCTION CRITERIA	
If patients have one of these criteria → Acute Organ Dysfunction → SEVERE SEPSIS - SBP <90 mmHG or MAP <65 mmHG and HR $\geq$ 100 - SBP decrease greater than 40 mmHG from baseline and HR $\geq$ 100 - New (or increased) oxygen requirement to maintain SP02 greater than 90% - Bilirubin greater than 2 mg/dl - Platelet count < 100,000 - Coagulopathy (INR greater than 1.5 or aPTT greater than 60 secs) - Lactate $\geq$ 2 mmol/L	
FOR SEVERE SEPSIS	
☒ IV fluid bolus 0.9% NS now (30 mL/kg) ☒ Strict Intake and Output. Notify MD urine output less than 0.5 mL/kg/hr ☒ Initiate Rapid Response Team If Systolic BP <90 or MAP <65 after initial fluid bolus, or lactate >3.9, NOTIFY MD ☒ Notify MD for signs of acute organ dysfunction criteria	
FOR SEPTIC SHOCK (Systolic <90, MAP <65 or Lactate greater than 3.9 mmol/L)	
☒ IV fluid bolus 0.9% NS now (30 mL/kg) ☒ Notify MD for transfer to ICU ☒ Notify MD for systolic BP less than 90, MAP less than 65 or lactate greater than 3.9 ☐ Place foley catheter with urometer ☒ Strict Intake and Output. Notify MD urine output less than 0.5 mL/kg/hr ☒ Initiate Rapid Response Team (if not already present) ☒ Initiate broad spectrum antibiotics within 60 minutes of "identified sepsis"	
Authorization for therapeutic substitution is given unless checked here ☐	
 Sutter Health Sacramento Sierra Region ☐ SAFH ☐ SAH ☐ SDH ☐ SMCS ☐ SRMC ☐ SSMC	Patient Identification _____ _____ _____
137400-100 (12/23/14) Perinatal Sepsis Orders	Page 1 of 2 ORDERS

BP = blood pressure; CBC = complete blood count; HR = heart rate; INR = international normalized ratio; IV = intravenous; LAT = lateral; MAP = mean arterial pressure; MD = physician; NS = normal saline; P = pulse; PA = posterioranterior; PTT = partial prothrombin time; R = respirations; RR = respiratory rate; SBP = systolic blood pressure; SIRS = systemic inflammatory response syndrome; UA = urinalysis; WBC = white blood cell count.

continued on next page

FIGURE 3 **SAMPLE PHYSICIAN ORDER SET (CONTINUED)**

+

+

☐ SCANNED TO PHARMACY
☐ STAT MEDICATION

* Infuse first antibiotic within the 1st hour and ensure both antibiotics are infused within 3 hours.
 * **If no antibiotics selected, notify MD immediately. Ensure blood cultures are obtained prior to antibiotic initiation.**

ANTIBIOTICS FOR SEVERE SEPSIS / SEPTIC SHOCK
Unknown etiology and/or currently on any above antibiotics

Discontinue all current antibiotic(s)

☐ Vancomycin 20 mg/kg (up to 2 gm) IV now and continue per pharmacy dosing:
AND one of the antibiotics below:

☐ Zosyn 4.5 gm IV now and continue per pharmacy dosing (**give first**):

OR

☐ For **Non Significant or Unknown** Penicillin Allergy:
 Cefepime 2 gm IV now and continue per pharmacy dosing

☐ For **Significant** Penicillin Allergy (*anaphylaxis, angioedema, respiratory distress, urticaria*):
 Aztreonam 2 gm IV now and continue per pharmacy dosing

OR

Gentamicin 5 mg/kg IV now and continue per pharmacy dosing

Additional orders: _____

Date: _____ **Time:** _____

Physician Signature: _____

Authorization for therapeutic substitution is given unless checked here ☐



137400-100 (12/23/14)

☐ SAFH ☐ SAH ☐ SDH ☐ SMCS ☐ SRMC ☐ SSMC

Perinatal Sepsis Orders

Patient Identification

Page 2 of 2
 ORDERS

BP = blood pressure; CBC = complete blood count; HR = heart rate; INR = international normalized ratio; IV = intravenous; LAT = lateral; MAP = mean arterial pressure; MD = physician; NS = normal saline; P = pulse; PA = posterioranterior; PTT = partial prothrombin time; R = respirations; RR = respiratory rate; SBP = systolic blood pressure; SIRS = systemic inflammatory response syndrome; UA = urinalysis; WBC = white blood cell count.

Table 4 displays cross tabulations for blood lactate level tested, broad-spectrum antibiotic administered, and repeat blood lactate level tested in perinatal women with positive screening results for sepsis preintervention and postintervention. For blood lactate level, the chi-square value was 4.442, with $df = 1$ with $p = .029$. Blood lactate level when comparing preintervention and postintervention results was statistically significant. For women receiving a broad-spectrum antibiotic, the chi-square value was 7.420, with $df = 1$ and $p = .006$. Statistical significance was achieved with p less than .01. For repeat blood lactate level, the chi-square value was 4.510, with $df = 1$ and statistical significance noted with $p = .034$.

Table 5 displays weighted cross tabulations for broad-spectrum antibiotic administered in perinatal women with severe sepsis and septic shock. When isolating cases for severe sepsis and septic shock, administration of a broad-spectrum antibiotic was examined preintervention and postintervention using cross tabulation. The chi-square value was 6.705, with $df = 1$ and statistical significance noted with $p = .010$.

DISCUSSION

A discussion of the findings includes common infections, bundle compliance indicators, and comparison of bundle compliance between perinatal women with sepsis and with severe sepsis and septic shock in preintervention and postintervention groups.

Common Infections

The most common infection was chorioamnionitis (46.4%), followed by pyelonephritis (14.4%). These findings are consistent

TABLE 1 FREQUENCY OF SEPSIS, SEVERE SEPSIS, AND SEPTIC SHOCK FROM APRIL 2014 THROUGH JANUARY 2015

Type of Sepsis	<i>n</i>	%
Confirmed sepsis positive	97	98.0
Severe sepsis	47	48.5
Septic shock	7	7.2

TABLE 2 SOURCES OF INFECTION FOR WOMEN DIAGNOSED WITH SEPSIS DURING PREGNANCY

Source of Infection	<i>n</i>	%
Chorioamnionitis	45	46.4
Pyelonephritis	14	14.4
Endometritis	5	5.2
Urinary tract infection	5	5.2
Unknown	29	29.0

TABLE 3 BUNDLE COMPLIANCE FOR SEPSIS, SEVERE SEPSIS, AND SEPTIC SHOCK BEFORE AND AFTER INTERVENTION, *n* (%)

Compliance Indicators	Before Sepsis (<i>n</i> = 31)	After Sepsis (<i>n</i> = 66)	Before Severe Sepsis (<i>n</i> = 13)	After Severe Sepsis (<i>n</i> = 34)	Before Septic Shock (<i>n</i> = 3)	After Septic Shock (<i>n</i> = 4)
Lactate level testing	23 (74.0)	60 (90.9)	13 (100.0)	33 (97.1)	3 (100.0)	3 (75.0)
Blood culture sample	12 (38.7)	29 (43.9)	6 (46.2)	19 (55.9)	2 (66.7)	3 (75.0)
Fluid bolus	20 (64.5)	48 (73.0)	10 (76.9)	25 (73.9)	2 (66.7)	4 (100.0)
Administer broad-spectrum antibiotic	24 (77.4)	63 (95.4)	10 (76.9)	33 (97.1)	2 (66.7)	4 (100.0)
Repeat lactate level testing	N/A	52 (79.0)	9 (69.2)	28 (82.4)	2 (66.7)	4 (100.0)
Bundle met	12 (38.7)	37 (45.5)	7 (53.8)	18 (52.9)	2 (66.7)	4 (100.0)

with literature stating that maternal sepsis is primarily the result of a pelvic infection due to chorioamnionitis, endometritis, urinary tract infections, and wound infections (Bauer, Bateman, Bauer, Shanks, & Mhyre, 2013; Guinn, Abel, & Tomlinson, 2007).

Bundle Compliance

Total bundle compliance was greater for all of the postintervention groups except for the severe sepsis groups, for which the preintervention group's findings were almost identical to those of the postintervention group (53.8% and 52.9%, respectively). Bundle compliance indicators were reviewed for significance in the preintervention and postintervention groups. Bundle compliance indicators reaching statistical significance when comparing preintervention and postintervention groups included blood testing for lactate level, repeat blood testing for lactate level, and administering broad-spectrum antibiotic(s).

Before receiving education and a protocol, physicians were reluctant for several reasons to order the interventions to manage sepsis when a woman had a positive screening result. First, in the early stages, a woman does not look septic, leading to the possible belief that treatment is not warranted. Second, this population is generally young and healthy, resulting in the belief that women with sepsis are overtreated.

We identified a knowledge gap for implementing sepsis bundles for early recognition at this early stage. According to Oud (2014), there are several explanations for this knowledge

gap. There is not an abundance of literature on maternal sepsis, and/or existing studies of maternal sepsis had small sample sizes. Of the studies reported, there was a variance in case definition of *sepsis* and *severe sepsis*. The adjusted SIRS criteria in perinatal patients were not consistent.

To address this knowledge gap, we displayed articles for clinicians to read about the importance of early recognition and management of maternal sepsis. A study by Kramer et al. (2009) reported that the time from the first symptom of sepsis to septic shock was less than 24 hours in 39% of women studied. For women who died of severe sepsis, the time from onset of infection to death was less than 24 hours in 50% of women.

In addition, we focused education for clinicians on providing the rationale for the adjustments of maternal parameters to reflect the physiology of pregnancy. The physician champion presented at meetings attended by physicians, and case scenarios were used to help clinicians examine how best practice could be incorporated into care. During work time, the perinatal registered nurse champions shared literature with physicians and discussed the new perinatal sepsis order set with physicians. These one-to-one interactions enabled clinicians to discuss concerns and fostered an intimate dialogue to problem-solve each individual patient situation.

Fears of antibiotic resistance or risk of pulmonary edema were realistic concerns among providers. However, pulmonary

TABLE 4 WEIGHTED CROSS TABULATIONS FOR LACTATE LEVEL AND REPEAT LACTATE LEVEL TESTING AND ANTIBIOTIC ADMINISTERED IN PERINATAL WOMEN WITH SEPSIS PREINTERVENTION AND POSTINTERVENTION

Time Period	Lactate Level Testing	Broad-Spectrum Antibiotic Administered	Repeat Lactate Drawn Level Testing
Preintervention, <i>n</i> (%)	23 (74.2)	24 (77.4)	18 (58.1)
Postintervention, <i>n</i> (%)	60 (90.9)	63 (95.5)	52 (78.8)
<i>p</i>	.029	.006	.034

TABLE 5 WEIGHTED CROSS TABULATIONS FOR BROAD-SPECTRUM ANTIBIOTIC ADMINISTERED IN PERINATAL WOMEN WITH SEVERE SEPSIS OR SEPTIC SHOCK

Time Period	Broad-Spectrum Antibiotic Not Administered, <i>n</i> (%)	Broad-Spectrum Antibiotic Administered, <i>n</i> (%)	<i>p</i>
Preintervention	4 (25.0)	12 (75.0)	.010
Postintervention	1 (2.6)	37 (97.4%)	

edema and antibiotic resistance are generally treatable, whereas mortality associated with severe sepsis is not. Physician champions and pharmacy champions helped to dispel these concerns. The effects of these educational interventions led to a greater understanding of the problem and a shared mental model about evidence-based solutions, and ultimately they are reflected in an overall increase in bundle compliance indicators in the postintervention group for patients with sepsis.

Lactate Level in Sepsis Patients

Bundle compliance for blood testing for lactate level and repeat testing for lactate level was significant in women with sepsis when comparing the preintervention and postintervention groups. Lactate level is the most widely used biomarker indicating organ dysfunction (Faix, 2013). The role of lactate level as a biomarker was met with resistance because of the possibility that lactate level could be falsely elevated in laboring women because of increased work of the skeletal muscles in labor. There have been no studies validating that serum lactate level could not be used as a biomarker in the perinatal population. Therefore, we decided that lactate level would be used as a biomarker for inadequate tissue perfusion in laboring women. We provided education to clinicians to avoid screening patients for sepsis during the second stage of labor, because the SIRS criteria could not be evaluated accurately. Perinatal clinicians were educated and coached to repeat blood testing every 6 hours until the lactate level was less than 2 mmol/L to ensure that lactate was clearing.

Broad-Spectrum Antibiotic for Sepsis

Administering a broad-spectrum antibiotic within 1 hour of presentation of sepsis reached statistical significance for women in all groups including sepsis, severe sepsis, and septic shock. Kumar et al. (2006) demonstrated that mortality is decreased with the early administration of a broad-spectrum antibiotic and that mortality increased by 7.6% with each hour of delay. The perinatal sepsis physician order set helped to guide clinicians in giving the appropriate antibiotic based on the source of infection. Antibiotics safe for use in pregnant women for common infections such as chorioamnionitis and pyelonephritis as well as treatment for severe sepsis and septic shock were included in the physician order set. Pharmacy champions presented at grand rounds and physician-attended meetings to provide education in choosing the right antibiotic for common obstetric infections and severe sepsis. Nurses were also educated in the appropriate selection of an antibiotic based on source of infection leading to a shared mental model for treatment among nurses and physicians.

Intravenous Fluid Bolus and Drawing Blood Culture Samples

The administration of an intravenous fluid bolus and blood culture testing did not reach statistical significance when comparing preintervention and postintervention groups. There was

a perceived assumption that perinatal women were receiving adequate intravenous fluids during labor and before epidural anesthesia placement for prevention of hypotension. In addition, there was the perceived risk of pulmonary edema secondary to large intravenous fluid boluses. The reluctance for blood culture testing was the perception that the source of infection was generally known and that it was not necessary in the early stages of sepsis.

Incidental Findings

There was an incidental finding noted during this project. There was a lack of consistency among physicians for using gold standard antibiotic regimens to treat common infections

Hospitals providing services for women in the perinatal period should develop standardized procedures and protocols for early recognition and management of maternal sepsis

and severe sepsis. The physician champion and pharmacist provided education for physicians regarding gold standard antibiotic treatment regimens at physician-attended meetings with improvement noted over time.

LIMITATIONS

There were limitations to this project. First, interventions during the planning phase affected the preintervention period of the project. The time period during which health records were reviewed did not strictly correspond to the preintervention and postintervention periods of time. The health records were reviewed from April 2014 through January 2015, but the project began in September 2013 with a draft perinatal sepsis order set that was discussed at several physician-attended committee meetings. Some physicians were compelled by the research on maternal sepsis and began using the recommended bundles for obstetric patients with positive sepsis screening results. The informal education began in September 2013. Therefore, this resulted in some bias for the preintervention group. It is assumed that greater statistical significance would have been reached if the health record review had begun in September 2013. In light of the preintervention data, however, best practice was definitely not hardwired, and opportunities for improvement were still available.

Another limitation to the project was the need to interpret some of the chart data. The nurses did not consistently document the administration of intravenous fluids appropriately. The researcher had to make inferences about fluid boluses according to the date and time of the physician's order.

IMPLICATIONS FOR NURSING PRACTICE

Protocols are recommended in the obstetric arena to include early warning signs for sepsis in perinatal women. According to the California Department of Public Health (2011), early signs of deteriorating condition can be difficult to recognize because critical illness is rare in normal pregnancy and childbirth. Developing early warning signs includes a clear expectation for observation with predefined criteria for assessment that triggers a response when an abnormality is present (Ivory, 2014). Adjusting SIRS criteria to account for the physiologic changes of pregnancy can assist clinicians with early detection and recognition and trigger a set of interventions for management of maternal sepsis.

Hospitals providing services for women in the perinatal period should develop standardized procedures and protocols for early recognition and management of maternal sepsis. Using the sepsis bundles to create a clinical protocol that fits the needs of the institution is essential for successful implementation (Surviving Sepsis Campaign, 2012). Developing protocols for management of maternal sepsis can help build a collaborative environment to facilitate change using evidence-based practice. Standardizing care can reduce errors in the delivery of care. Protocols should include all elements of sepsis bundles while allowing flexibility for the needs of the hospital. Reliability of the bundles has been established to reduce mortality by 25% in patients with sepsis (Surviving Sepsis Campaign, 2012).

Documentation of intravenous fluids is critical when a woman has a positive screening result for sepsis. Urinary output is a sign of organ dysfunction; therefore, strict intake and output is necessary for women with sepsis. When a woman develops severe sepsis and septic shock, large amounts of intravenous fluids are given, and it is critical to know the timing and quantity of fluids administered.

The importance of an implementation plan that uses interprofessional education, a standardized protocol, and a multidisciplinary team cannot be overemphasized. It is important to form multidisciplinary teams to develop protocols and guidelines for managing any quality improvement process, including maternal sepsis. Multidisciplinary teams include experts, front-line clinicians, pharmacists, physicians, rapid response team members, emergency room nurses and physicians, and other health care professionals who are affected by the protocol. Including a diverse group of experts allows for identification of problems with the new patient standard through a multidisciplinary approach.

The use of the Iowa Model (Titler, 2010) supported this project at an organizational level. Implementing education and a perinatal sepsis physician order set required teamwork. This project involved multiple departments working together to improve patient safety. Before implementing education and the physician order set, a small group of stakeholders collaborated to research the guidelines to create the physician order set. During the planning stage, the Iowa Model supported the evaluation of case studies, expert opinions, and scientific principles before disseminating information out to health care professionals. This step

was important, because health care professionals are exposed to change daily. How well planned a change project is can be a key factor in determining whether it is adopted or eliminated.

Physician and nurse champions mentored other health care professionals during the change process. Including front-line staff in decision-making and rollout helps to overcome opposition in a manner that allows them to incorporate new ideas into the process and convert possible opponents into supporters (Porter-O'Grady & Malloch, 2011). The nurse champions disseminated information to staff and mentored them on the new process. Creating opportunity for small successes to occur early during implementation of innovation will motivate those individuals most affected by the change (Porter-O'Grady & Malloch, 2011). People will not be motivated unless they feel their efforts will make a difference.

Organizational context was important to consider. The hospital where the project took place was in the midst of preparing to move into a new building and to implement an electronic health record, all on the same day. In addition, the department had recently finished an 18-month quality improvement project focused on practice changes for preeclampsia. Resources were minimal, and the leadership team was somewhat distracted by other commitments. The success of this project is a testament to the strength of bedside nurses, in collaboration with other key stakeholders, to engage, energize, and achieve outcomes in the midst of organizational stress. In addition, bedside nurses have the unique understanding of clinicians' concerns and have their ear when real-time orders and decisions are being made. The use of the Iowa Model (Titler, 2010) has provided a structure to implement quality improvement strategies involving multiple departments in a tertiary care hospital.

CONCLUSION

The purpose of our project was to evaluate staff compliance with early goal-directed therapy before, during, and after the implementation of a standardized physician order set and interprofessional education for nurses and physicians. SIRS criteria were adjusted for consideration of the physiologic effects of pregnancy to accurately screen for sepsis. When determining the effects of interprofessional education and a physician order set, statistical significance was achieved for blood testing for lactate level, administering a broad-spectrum antibiotic, and repeat lactate level testing in women with sepsis. In addition, statistical significance was achieved for administering a broad-spectrum antibiotic for women with severe sepsis and septic shock, with 100% compliance achieved for both these diagnoses.

Further research is needed to examine physiologic criteria and laboratory values for screening women at risk for sepsis in the perinatal period. In addition, more research is needed to correlate the use of early goal-directed therapy with positive health outcomes, such as decreased intensive care unit admissions and shorter hospital lengths of stay. **NWH**



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Post-Test Questions

Instructions: To access this CNE activity online, visit <http://www.awhonn.org/?OnlineLearningCenter>. CNE for this activity is available **online only**; written tests submitted to AWHONN **will not** be accepted.

1. During pregnancy which physiologic change occurs?
 - a. Cardiac output decreases
 - b. Respiratory rate increases
 - c. White blood cell count increases
2. Lactate is a widely used biomarker for which condition?
 - a. Organ dysfunction
 - b. Polyhydramnios
 - c. Tissue hyperperfusion
3. Which of the following is one of the SIRS criteria that were adjusted in this project to account for normal physiologic changes of pregnancy?
 - a. Body temperature
 - b. Respiratory rate
 - c. White blood cell count
4. Which of the following is a reason for pregnant women's increased susceptibility to infections?
 - a. The maternal immune response in pregnancy is decreased to protect the immunologically distinct fetus.
 - b. The maternal immune response in pregnancy is increased to protect the immunologically distinct fetus.
 - c. The maternal immune response in pregnancy remains unchanged to protect the immunologically distinct fetus.
5. Chorioamnionitis is a common obstetric complication occurring in approximately what percentage of term pregnancies?
 - a. 1% to 5%
 - b. 5% to 10%
 - c. 20% to 25%
6. Using a systematic health record review, the authors measured compliance to the indicators of early goal-directed therapy before, during, and after implementation of what?
 - a. A new screening protocol for maternal sepsis and education for nurses and physicians.
 - b. A perinatal sepsis physician order set and education for nurses and physicians.
 - c. A targeted sepsis treatment protocol using broad-spectrum antibiotics and education for nurses and physicians.
7. After chorioamnionitis, what was the second most common infection in this study population?
 - a. Endometritis
 - b. Pyelonephritis
 - c. Surgical wound infection
8. What percentage of infections among women in this study were of an unknown origin?
 - a. 5%
 - b. 14%
 - c. 29%
9. According to Table 3, for which condition was compliance with the care bundles not higher after the intervention?
 - a. Sepsis
 - b. Septic shock
 - c. Severe sepsis
10. In a study by Kramer et al. (2009), what percentage of women who died of severe sepsis died in less than 24 hours from the time from onset of infection?
 - a. 15%
 - b. 30%
 - c. 50%