



Group A Streptococcal Infection During Pregnancy and the Postpartum Period

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ABSTRACT: Group A *Streptococcus*, the causative organism for “childbed fever,” continues to pose a threat to women during pregnancy and the postpartum period, despite advances in hygiene and the development of antibiotic therapy. This resilient bacterium has resurfaced with intensified virulence, and, for reasons not entirely clear, causes severe disease in some women. Sepsis and toxic shock syndrome caused by Group A *Streptococcus* contribute to the alarming rates of maternal morbidity and mortality in the United States. Early recognition of the subtle signs and symptoms of sepsis is critical to decrease the risk for mortality; however, early signs can be elusive during the perinatal period because of the physiologic changes of pregnancy. Care management requires a coordinated, collaborative, multidisciplinary team approach. Sepsis is a clinical emergency, and health care providers need to respond as a well-prepared team.

doi: [10.1016/j.nwh.2019.11.006](https://doi.org/10.1016/j.nwh.2019.11.006)

Accepted November 2019

KEYWORDS: Group A strep, Group A *Streptococcus*, maternal mortality, perinatal infection, sepsis, toxic shock syndrome

After 9 months of expectation, prenatal screening and scrutiny, and the intensity of labor and birth, postpartum care appears to focus on education about newborn care and discharge. A crucial component, however, for medical and nursing care is surveillance for and prevention of postpartum complications. Although rates of maternal

mortality are decreasing in many countries around the world, in the United States, they have more than doubled over the past two decades, with more than half of all maternal deaths occurring during the postpartum period (Kleppel, Suplee, Stuebe, & Bingham, 2016). It is estimated that nearly 60% of maternal deaths are preventable (Zelop, 2018).

CLINICAL IMPLICATIONS

- Infections are one of the leading causes of perinatal morbidity and mortality.
- Physiologic changes during pregnancy and the postpartum period predispose women to infection and may render early diagnosis of infection challenging.
- Group A *Streptococcus* has the potential to cause invasive disease, including postpartum endometritis and necrotizing fasciitis.
- Invasive Group A streptococcal infections can progress rapidly to sepsis and toxic shock syndrome, demanding timely and accurate nursing assessment skills.
- A multidisciplinary focus is required in the prevention, surveillance, and early intervention for Group A streptococcal infection and sepsis to achieve optimal outcomes.

Infection is a significant contributor to maternal morbidity and mortality; it is the third leading cause of maternal mortality, and the number of infection-related maternal deaths is rising (Martin & McMurtry Baird, 2018). The major organisms causing fatal perinatal infections are *Escherichia coli* and coliforms, *Streptococcus pneumoniae*, and *Streptococcus pyogenes*, also known as Group A *Streptococcus* or GAS (Morgan, 2017).

GAS is a common pathogen with a deleterious reputation as the causative organism for childbed fever (i.e., puerperal infection), and it has received media attention as the flesh-eating (necrotizing fasciitis) bacteria. GAS also received national attention in the 1980s for its association with toxic shock syndrome related to the use of large tampons with high absorbency. Unlike Group B *Streptococcus* (see Table 1), which generally does not cause serious maternal morbidity and is vaginally colonized in about 20% of women, GAS is not routinely colonized in the female reproductive tract (Mason & Aronoff, 2012). GAS infections are now reemerging with increased virulence, although early diagnosis and treatment can improve survival and minimize complications. Women in the postpartum period are 20 times more likely to become infected with GAS than other women (Gustafson, Blaakaer, & Helmig, 2017).

Diagnosis can be challenging because the initial symptoms are often nonspecific and subtle, and although women in the postpartum period are at greater risk for GAS infection, it is relatively uncommon and, therefore, more likely to be overlooked. During late pregnancy, the early signs of infection may be associated with long prodromal labor (Parfitt & Hering, 2018). Low-grade fever, myalgia, nausea, and malaise are frequently reported symptoms among women in the

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postpartum period. Abdominal pain can be attributed to afterbirth pains or postoperative pain. Anesthesia and analgesia can mask early signs of infection and sepsis such as pain and fever (see Box 1 for a case example).

After early postpartum discharge from a hospital, women may not recognize potential danger signs and may not seek immediate health care. Infection can occur in the absence of distinct risk factors such as prolonged rupture of membranes or prolonged labor, and it often occurs in otherwise healthy women with no comorbidities or labor complications; this type of scenario can cloud clinicians' suspicion in recognizing early signs and symptoms of infection. Furthermore, postpartum units typically experience sometimes drastic fluctuations in census, and busy nurses and other clinicians can miss subtle signs of infection or may lack the experience and skills needed to identify early warning signs of sepsis (Morgan, 2017). Because GAS sepsis can progress rapidly, nurses must not only identify early signs and symptoms but also intervene in a timely and appropriate manner, as well as to understand infection control issues associated with this deadly pathogen.

Infection and Pregnancy

Childbearing predisposes women to infection for a variety of reasons. Pregnancy is an obligatory state of altered immunity necessary to prevent rejection of the fetus as a foreign body. The antibody-mediated immune response is suppressed, placing women at risk for certain viral, bacterial, and parasitic infections (Orr & Chien, 2015). Alterations in the renal system occur as the result of hormonal influences, pressure from the enlarging uterus, and an increase in maternal blood volume. The renal pelvis and ureters dilate, and the weight of the gravid uterus results in mechanical compression, which may partially obstruct the flow of urine through the ureters. The resulting stasis of urine facilitates bacteriuria and increases the risk of urinary tract infections and pyelonephritis, the leading cause of sepsis in pregnant women (Morgan & Roberts, 2013). Glucose excretion is also increased during pregnancy, and glycosuria provides an ideal environment for bacterial growth. Another concerning infection is chorioamnionitis, the most common cause of preterm labor. Ascending infection from the lower genital tract after rupture of membranes is often the culprit; however, chorioamnionitis can also develop in women with intact membranes. Although Group B *Streptococcus* colonization is a more common risk factor, amniotic fluid provides a suitable medium for growth of GAS as well (Burke-Sosa, 2016). Morbidity and mortality due to pneumonia in pregnancy are also increased. Physiologic changes to the lungs during pregnancy include a 20% to 40% increase in oxygen consumption and decreased residual

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TABLE 1 GROUP A VERSUS GROUP B STREPTOCOCCUS

Characteristic	<i>Streptococcus pyogenes</i> (Group A)	<i>Streptococcus agalactiae</i> (Group B)
Common sites of colonization	Throat and skin	Intestinal and genital tracts
Manifestations	Impetigo	Asymptomatic bacteriuria
	Strep throat	Urinary tract infection
	Scarlet fever	Pyelonephritis
	Cellulitis	Postpartum endometritis
	Invasive disease	Amnionitis
	Necrotizing fasciitis	Neonatal infection (e.g., meningitis, pneumonia)
Source	Community acquired Nosocomial	Ascending
	Descending (originating in respiratory tract)	Passage through birth canal
Screening	No routine screening Pharyngeal culture in pregnant women with upper respiratory infection symptoms	Vaginal and rectal culture at 35–37 weeks gestation (plus urine culture considered with heavy colonization)
Treatment	Penicillin	Amoxicillin or cephalexin for urinary tract infection Prophylactic intrapartum antibiotics
	Clindamycin	
	Source control (e.g., debridement, hysterectomy)	
Sequelae	Toxic shock syndrome, rheumatic fever, glomerulonephritis	Neonatal infection and/or death, intrauterine fetal demise
Risk factors	Postpartum period, comorbidities, history of upper respiratory symptoms or risks (e.g., exposure to children)	Vaginal colonization, urinary tract infection (Group B <i>Streptococcus</i>), previous pregnancy with neonatal infection, premature rupture of membranes, preterm birth
Onset of symptoms	Rapid	Neonatal
	Postpartum (usually 1–2 days)	Early onset (within 24 hours of birth) Late onset (up to 30 days after birth)

Note. Sources: Lees and Carrol (2014); Kennedy and McMurtry Baird (2016); Schween and Novatnack (2003); Wong and Stevens (2013).

volume. Additionally, a decrease in lower esophageal sphincter tone allows for more frequent episodes of acid reflux and possible aspiration of gastric contents. Such changes contribute to increased incidence and severity of respiratory infections during pregnancy (Morgan & Roberts, 2013). Although GAS does not commonly cause pneumonia, there is some observation that the incidence of GAS pneumonia may be increasing (Wong & Stevens, 2013).

The most significant risk factor for any postpartum infection, including GAS, is cesarean birth (Arulkumaran & Singer, 2013). Invasive procedures, regional anesthesia, intravenous (IV) lines, and indwelling catheters all increase a woman's risk for infection. Even women who experience an uncomplicated vaginal birth are likely to have compromised mucosal barriers related to vaginal tears, the open cervix, and the alteration in vaginal pH after rupture of membranes. The postpartum uterus can be a conducive environment for invading

organisms where blood and necrotic decidual tissue support bacterial growth (Cooper et al., 2017).

Preexisting maternal disease (e.g., comorbidities) is a risk factor for perinatal infection. Stemming from a tide of women with chronic health conditions pursuing pregnancy and motherhood is a rising high-risk perinatal population. More than 50% of perinatal sepsis deaths occur in women who have at least one comorbidity (Society for Maternal-Fetal Medicine, Plante, Pacheco, & Louis, 2019). Anemia, poor nutrition, and impaired glucose tolerance are risk factors for infection and sepsis. An increasingly vulnerable population is pregnant women with obesity. In the United States, one third of reproductive-age women have a body mass index of 30 kg/m² or greater (Hirshberg & Srinivas, 2017). Adipose tissue plays a role in immune function, and obesity may result in immune suppression. Furthermore, women with obesity have been shown to have elevated levels of inflammatory cytokines and

BOX 1 CASE EXAMPLE

S.J., a 31-year-old woman who was pregnant for the second time with a history of a previous full-term birth, was admitted in active labor at 12:30 p.m. She had an uneventful pregnancy and no significant past history. Her previous pregnancy history included an uncomplicated vaginal birth 11 years earlier of a full-term, healthy daughter. S.J. was divorced, and her sister was present as her support person. At 3:45 p.m., S.J. experienced rupture of membranes of clear fluid, and at that time her cervix was 5 cm dilated and 90% effaced at a -1 station. S.J. requested epidural anesthesia. Her labor progressed without complication, and she was fully dilated with an urge to push at 6:21 p.m. She had a spontaneous vaginal birth with an intact perineum at 6:36 p.m. of a baby boy with Apgar scores at 1 and 5 minutes of 9 and 9, respectively, and the newborn was placed skin to skin immediately after birth for the next hour and breastfed. The placenta was delivered spontaneously 3 minutes after the newborn's birth, and 10 units of oxytocin in 500 ml Lactated Ringer's solution was infused over 2 hours prophylactically. Mother and newborn remained stable and were transferred to the postpartum unit at 9:00 p.m. S.J. voiced a desire for discharge the next day, and she and her newborn son were to be discharged the next evening pending completion of newborn screening. Postpartum assessment and vital signs on the morning after the birth remained within normal limits. The newborn was breastfeeding well and exhibited stable temperature and vital signs, good color and tone, and a lusty cry. A follow-up appointment had been scheduled with the pediatrician in 2 days.

As the nurse was reviewing discharge instructions, S.J. reported feeling lightheaded and nauseated, stating, "I feel like I'm getting the flu." Her temperature was 37.9 °C, pulse was 116 beats/minute, respirations were 20 breaths/minute, and blood pressure was 100/61 mmHg (baseline = 110/69 mmHg). She reported lower abdominal discomfort and uterine tenderness with fundal assessment, although the fundus was firm and was one fingerbreadth below the umbilicus. Lochia was rubra and moderate in amount, with no clots or odor. Her skin was hot and dry, with facial flushing noted. The physician was notified and cancelled the discharge order. One hour later, her temperature was 38.9°C, pulse was 126 beats/minute, respirations were 22 breaths/minute, and blood pressure was 91/54 mmHg, and she reported having chills. She continued to report nausea, lower abdominal pain, and feeling "really sick." Blood, vaginal, and urine cultures were drawn. Computed tomography scans of the chest and abdomen were also performed. Her condition continued to deteriorate, she became lethargic, and her blood pressure dropped to 70/50 mmHg. Her tachycardia persisted. She had developed a macular red rash over her abdomen, chest, and upper legs. S.J. was transferred to the ICU. Serum lactate level was drawn and returned elevated at 4.2 mmol/L. She was started on a vasopressor infusion to maintain her blood pressure and received oxygen by non-rebreather mask, allowing her to maintain oxygen saturations levels of greater than 93%. An infectious disease physician was consulted, and she was started on ampicillin/sulbactam and intravenous metronidazole because of concern for intraabdominal abscess.

S.J.'s condition continued to be tenuous over the next 24 hours. Her blood pressure hovered around 90/70 mm Hg, and her temperatures ranged from 36.0°C to 39.5°C. Blood and vaginal culture results were positive for *Streptococcus pyogenes*, or Group A *Streptococcus*, and the infectious disease physician changed her antibiotic regimen to intravenous penicillin G and clindamycin. Her labile temperatures, unimproved clinical status, and concern for progression to necrotizing fasciitis prompted the decision to perform an emergent hysterectomy to remove the source of infection.

S.J.'s hysterectomy was uncomplicated, and she returned to the ICU for monitoring. Over the next 12 hours, her blood pressure hovered around 100/90 mm Hg, and vasopressors were discontinued. Her temperature decreased to 37.2°C, and she continued to stabilize. She continued receiving intravenous penicillin G and clindamycin, and after another 24 hours, she was transferred to a regular floor with a good clinical prognosis. S.J. continued to improve, and 4 days later was discharged on penicillin for 10 more days, with postpartum follow-up scheduled.

monocytes. Potentially, this chronic state of inflammation renders the immune system less responsive to the threat of infection (Orr & Chien, 2015).

Additionally, contact with health care professionals can be a source of infection during pregnancy. GAS in particular can be spread from person to person by contact with an asymptomatic carrier. Although the incidence of puerperal infection (then known as *childbed fever*) and death decreased significantly after the hand hygiene initiatives of Dr. Ignac Semmelweis in 1847, perinatal infections continue to be a threat today.

About Sepsis and Septic Shock

Not all women who are pregnant or in the peripartum period who have a GAS infection will develop sepsis. However, the physiologic adaptations of pregnancy can not only make early diagnosis more challenging, but can also intensify the systemic manifestations of sepsis. During pregnancy and the postpartum period, women often experience a precipitous progression from initial signs of infection to septic shock and death (Chebbo, Tan, Kassis, Tamura, & Carlson, 2016). The incidence of pregnancy-associated sepsis has increased

dramatically over the past decade and, along with hemorrhage and complications of hypertension, sepsis is among the leading causes of critical illness and ICU admission among pregnant women (Chebbo et al., 2016). Women who experience pregnancy-associated sepsis are at risk for long-term consequences, including chronic pelvic inflammatory disease, chronic pelvic pain, and infertility (Arulkumaran & Singer, 2013). Pregnancy-associated sepsis can also affect neonatal health outcomes, increasing the risk for preterm birth and intrauterine fetal death. Neonatal infection remains a prominent factor in neonatal morbidity and mortality.

In addition to the life-threatening consequences of sepsis and septic shock, the financial impact of these diagnoses is astronomical. Sepsis is the most costly reason for hospitalization in the United States (Jain, 2018). To improve outcomes, early diagnosis and treatment are essential.

Sepsis Definition

The Surviving Sepsis Campaign, a collaboration between the Society of Critical Care Medicine and the European Society of Intensive Care Medicine, has published global initiatives focused on early recognition and prompt treatment. Sepsis has been defined by the Surviving Sepsis Campaign expert panel as a life-threatening organ dysfunction caused by a dysregulated host response to infection (Jain, 2018).

Sepsis Pathophysiology

The pathophysiology of sepsis is complex, with numerous imbalances affecting multiple organ systems. The hyper-inflammatory state resulting in end organ dysfunction can be triggered in immune-suppressed or immune-stimulated individuals (Remick, 2007). There is a widespread unleashing of proinflammatory mediators and cytokines and activation of the complement system. Generalized and widespread cellular injury causes metabolic derangement, tissue ischemia, and coagulation deficits leading to disseminated intravascular coagulation and results in endothelial damage, vasodilation, and hypovolemia (Chebbo et al., 2016; Remick, 2007).

Women with sepsis may be edematous because increased capillary permeability can cause fluid transference to the extravascular spaces; however, they are hypovolemic because they have decreased intravascular volume. Multiple organ dysfunction syndrome results from impaired tissue perfusion and cell death associated with sepsis and severe inflammation. Organ systems commonly affected are the respiratory, renal, hepatic, gastrointestinal, cardiovascular, and nervous systems. A woman may develop acute respiratory distress syndrome that requires mechanical ventilation to treat hypoxemia, renal failure with serum creatinine levels of 2 mg/dl or greater, and jaundice with elevated liver enzymes and serum bilirubin level of 2 mg/dl or greater and may experience gastrointestinal bleeding or decreased peristalsis, disseminated intravascular coagulation, altered levels of consciousness, and ultimately coma and death.

Sepsis Diagnosis and Scoring Tools

A challenge in diagnosing sepsis during pregnancy and the early postpartum period is that the physiologic adaptations of pregnancy often coincide with the hemodynamic changes of early sepsis: progesterone stimulates maternal vasodilation, labor and postpartum pains can result in tachycardia, and elevation of the diaphragm in pregnancy and increased oxygen consumption result in mild tachypnea. Furthermore, the white blood cell count is normally elevated during pregnancy and early in the postpartum period, making this a less sensitive diagnostic parameter. Additionally, systemic inflammation in labor and the early postpartum period could arise secondary to the use of prostaglandins for labor induction or the treatment of postpartum hemorrhage. Ultimately, the failure of clinicians to recognize early signs of sepsis can result in costly delays in treatment (Burlinson, Sirounis, Walley, & Chau, 2018).

Several scoring systems have been devised to guide health care providers in identifying women at risk for sepsis and prompt early identification of signs and symptoms, as well as to predict organ dysfunction and the need for a higher level of care. A rapid screening tool has been used to identify women at risk for adverse outcomes related to sepsis, the quick Sepsis Related Organ Failure Assessment (qSOFA). Three parameters are assessed: respiratory rate, systolic blood pressure, and mental status (Glasgow Coma Scale). The Society for Obstetric Medicine Australia and New Zealand advocates the use of a modified qSOFA scale with considerations for physiologic changes of pregnancy. Women at risk must meet at least two of the following criteria: respiratory rate of 25 breaths per minute or greater, systolic blood pressure less than 90 mmHg, and altered mental status with a Glasgow Coma Scale score of less than 15 (Society for Maternal-Fetal Medicine et al., 2019).

Additional obstetrics-specific sepsis screening tools are the Sepsis in Obstetrics assessment, which also quantifies temperature, peripheral capillary oxygen saturation (SpO₂), white blood cell count (including the percentage of immature neutrophils), and lactic acid level (Albright, Ali, Lopes, Rouse, & Anderson, 2014), and the Maternal Early Warning Trigger Tool, which is intended to facilitate prompt assessment of women at risk for hemorrhage, hypertension, sepsis, and cardiopulmonary compromise to ensure timely intervention (Parfitt & Hering, 2018). Although sepsis scoring systems can be useful in establishing a rapid diagnosis, these instruments have limitations and may still require validation.

Septic Shock

Septic shock is the presence of sepsis criteria plus hypotension despite sufficient fluid resuscitation. The woman typically manifests signs of hypoperfusion including lactic acidosis, oliguria, or change in mental status. These individuals typically require vasopressors to maintain blood pressure and have a significantly increased mortality rate (Plante, 2016).

Tissue hypoperfusion results in a vicious cycle of systemic inflammation, myocardial dysfunction, third space fluid extravasation, or capillary leakage resulting in edema, hypovolemia, impaired cellular exchange of O₂ and CO₂, and ultimately death if intervention fails to halt this sequence of events.

Emergence of GAS Infection

Despite modern advances in health care, such as improved sanitation and the development of antibiotics, there lurks a big bad wolf with a new disguise. GAS is not a new pathogen, but the epidemiology has changed. There are more than 120 strains of GAS of varying degrees of virulence (Schweon & Novatnack, 2003). Increasingly virulent strains of GAS have emerged over the past two decades, contributing to increasing rates of maternal morbidity and mortality from puerperal infections, despite the fact that there does not appear to be any increase in GAS antibiotic resistance (Mason & Aronoff, 2012). Hughes (2018) raised concern that GAS infection may be surfacing as a new obstetric concern and calls the increase in puerperal GAS infection “astronomical” (Hughes, 2018, p. 54).

GAS is an adaptable Gram-positive, β -hemolytic organism that causes a wide range of infections, ranging from mild pharyngitis and impetigo to severe and invasive disease, including pneumonia, meningitis, and endometritis. Humans are the only known host, and the bacteria are carried asymptomatically on the skin or in the throat of an estimated 5% to 30% of the population and spread by direct contact or aerosolization from person to person (Mason & Aronoff, 2012). The organism is not normally colonized in the female reproductive tract; however, it is theorized that self-contamination can occur in women with a recent history of GAS pharyngitis. Children and adolescents have a greater rate of colonization of GAS than do adults, and the majority of pregnancy-related GAS infections are community acquired, especially in women who have frequent contact with children at home or work (Nguyen et al., 2018). GAS infection can be associated with serious complications, including rheumatic fever and glomerulonephritis. Nosocomial infection is an ongoing threat in obstetrics because GAS has been associated with periodic upsurges in perinatal infections, particularly endometritis.

GAS bacteria use several virulence factors to impede immune response. A hyaluronic acid capsule and carbohydrate cell wall antigens differentiate these organisms from other streptococcal species and allow the bacteria to avoid phagocytosis by macrophages and neutrophils (Cooper et al., 2017). Another virulence factor of GAS is its capacity to adhere to host cells, resulting in colonization. M (emm) proteins found on the cell surface of GAS inhibit immune response by interfering with phagocytosis and antibody response to pathogens, allowing

the organism to multiply rapidly, leading to invasive disease. More than 200 types of M proteins have been identified, with M1 and M28 being more commonly associated with postpartum infection (Brahmadathan, 2017; Nguyen et al., 2018). Bacterial antigens are associated with toxic shock syndrome, and streptococcal pyogenic exotoxins are considered to be superantigens capable of activating T cells and stimulating the release of large amounts of cytokines and immune modulators, resulting in activation of the complement, coagulation, and fibrinolytic pathways (Gustafson et al., 2017).

Toxic shock syndrome is a life-threatening sequelae of invasive GAS infections with a clinical progression similar to septic shock. Women may initially have a macular red rash, usually over the upper chest, along with flu-like symptoms. Plantar and palmar desquamation may appear a few days after the onset of initial symptoms, characteristic of toxic shock syndrome (Schmitz, Roux, Huttner, & Pugin, 2018). Toxic shock syndrome is diagnosed when GAS is isolated from a normally sterile site or from a nonsterile body site when there are two or more clinical signs of severity present, such as erythematous rash, coagulation dysfunction, respiratory distress, impaired liver function, extensive tissue necrosis, and renal damage (Lees & Carol, 2014).

The pathogenesis of GAS is not fully understood; however, it is thought that genetic and host factors play a significant role in the development of invasive disease (Mason & Aronoff,

2012). GAS colonization results in a range of disease manifestations, the severity of which varies among individuals. As with some other infections, more women are colonized with GAS than

those who manifest disease symptoms. These data suggest that some women are more resistant to the GAS organism. Certain M protein strains of GAS are known to cause more invasive disease with a greater risk of mortality. Levels of cytokine production are correlated with disease severity. Women in the postpartum period may be at increased risk for GAS infection due to alterations in the endometrium. Transitional cells in the involuting uterus express vimentin, a protein found to be a GAS adhesion, and M2 macrophages preponderate in the involuting uterus, resulting in a dearth of proinflammatory macrophages that could potentially increase a woman's susceptibility to bacterial invasion (Hamilton, Bayer, Stevens, Lieber, & Bryant, 2008; Hamilton, Stevens, & Bryant, 2013). Prostaglandin production during pregnancy suppresses maternal immune function, and increased levels are associated with host susceptibility to GAS infection (Mason & Aronoff, 2012). Recent upper respiratory infection with pharyngeal colonization before childbirth is a host risk factor (Shinar et al., 2016). Other risk factors include skin lesions, diabetes, heart disease, IV drug use, varicella infection, and poor living conditions. GAS infections are more prevalent in the winter and spring.

Increasingly virulent strains of Group A *Streptococcus* have emerged over the past two decades



Collaborative Care Management

The goals in treating sepsis and septic shock are early recognition and aggressive intervention to reduce the risk of complications and mortality. Management needs to be collaborative and multidisciplinary to improve outcomes and decrease mortality rates. Nurses are on the front line for identifying initial signs of sepsis because they usually have the most consistent and frequent contact with a woman and are often the first to observe changes in her status.

Nurses need to identify subtle changes in a woman's status that can lead to compromise. Assessment of respiratory status is crucial because this is often the first indicator of declining physiologic status. Women with sepsis compensate by increasing the rate and depth of respirations in response to lactic acidosis. Hypoxia also causes a rise in respiratory rate as the body attempts to increase oxygenation. Women with suspected sepsis should have a pulse oximeter placed, and if the saturation is less than 95%, oxygen should be administered via a non-rebreather mask. Vital signs should be monitored frequently, including manual assessment of pulses and blood pressure, which is more accurate. The individual should be placed on a cardiac monitor because arrhythmias can occur with hypovolemia and sepsis. Women with sepsis and septic shock can have skin that is hot with a flushed appearance or pale, cool, and clammy, especially the extremities. Capillary refill should be assessed because it can indicate decreased peripheral perfusion. These women may initially have an increased systolic blood pressure with a decreased diastolic pressure, consistent with the early hyperdynamic phase of sepsis; however, the systolic

pressure will then decrease as the hemodynamic status deteriorates (Vaughn & Parry, 2016a). When sepsis is suspected, vascular access should be established as expediently as possible, and blood should be drawn and sent to the laboratory.

Alteration in mental status is also a critical indicator of change in a woman's status. Early neurologic changes may include headache, irritability, euphoria or restlessness, and anxiety. Confusion or decreased level of responsiveness may result from cerebral hypoperfusion and hypoxia and metabolic derange-

ment. A Glasgow Coma Scale score of less than 15 is a significant red flag. Women with sepsis often report feeling the worse than they've ever felt or "as if I might die." Mental status alterations are a safety concern. A woman who is confused is at greater risk for falling or injury. Individuals with decreased levels of consciousness are at risk for airway compromise and aspiration (Vaughn & Parry, 2016a). Nurses should remain at the bedside until the woman can be transferred to higher-level care.

Pain is often referred to as the fifth vital sign, and meticulous pain assessment can serve to warn a nurse of impending complications. Pain out of proportion to what is expected can be a sign of necrotizing fasciitis. Monitoring fluid balance is an essential nursing function because this is an indicator of hemodynamic stability and renal function. Urine output should be measured and recorded hourly; inserting a urinary catheter can facilitate accurate output measurement. Urine output can be useful in assessing adequacy of fluid resuscitation. Urine output for pregnant women should be at least 0.5 ml/kg, hourly. Additional manifestations of organ dysfunction are significant edema, jaundice, ileus, and, for a woman who has had a cesarean birth, absent bowel sounds.

The goals in treating sepsis and septic shock are early recognition and aggressive intervention to reduce the risk of complications and mortality

Nurses should continually assess a woman's status for signs of improvement, including increased urine output and blood pressure, decreased serum lactate, and C-reactive protein levels.

Nurses in the perinatal area promote family-centered care. A spouse or significant other and other family members need support when a woman is critically ill. Nurses can act as liaisons between the family and health care team, facilitating communication and providing education as needed. Family members may need a place to sleep, food, and assistance with navigating the health care system to access available resources. Social services should be consulted. If the woman is breastfeeding, nurses can assist her with pumping to maintain milk supply, and a lactation consultant, if available, should be consulted.

The Surviving Sepsis Campaign has developed evidence-based guidelines for the management of sepsis and septic shock, recently revising these guidelines to establish a single 1-hour bundle. Within 1 hour of suspicion of sepsis, bloodwork and other cultures should be obtained, a sample for serum lactate level should be drawn, and fluid resuscitation with crystalloids and broad-spectrum antibiotics should be administered. If the woman is exhibiting signs of septic shock or persistent hypotension during or after the initial fluid bolus, vasopressors should be initiated (Schorr, 2018).

The Surviving Sepsis Campaign recommends norepinephrine as the drug of choice to maintain mean arterial pressure, although a target mean arterial pressure for pregnant and previously young, healthy women has not been established (Burlinson et al., 2018). Lactate is a surrogate marker for tissue hypoperfusion and hypoxia subsequent to anaerobic metabolism. If the serum lactate level is elevated (>2 mmol/L), the test should be repeated to assess lactate clearance. A lactate level of 4 mmol/L correlates with severe sepsis (Morgan & Roberts, 2013). Albright, Ali, Lopes, Rouse, and Anderson (2015) studied lactic acid measurements in pregnancy and found that higher levels correlated with more adverse outcomes and severe sepsis, suggesting that a lower serum lactate level during pregnancy could signal sepsis (Parfitt & Hering, 2018).

Cultures should be taken before antibiotics are started. However, delaying antibiotics for more than 45 minutes increases the risk for mortality (Vaught, 2018). Two sets of blood cultures (both with aerobic and anaerobic bottles) should be drawn, along with any other appropriate cultures such as urine, wound, tissue, sputum, and amniotic fluid. Establishing the source of infection is crucial in management. Broad-spectrum antibiotics are administered for GAS; a β -lactam such as penicillin is considered the first-line treatment. The addition of clindamycin is recommended because it has been found to suppress bacterial toxins, inhibit M protein synthesis, and inhibit tumor necrosis factor (Gustafson et al., 2017). Women who are allergic to penicillin may be prescribed daptomycin or vancomycin.

C-reactive protein is a marker for bacterial sepsis, and rapidly rising levels (>200 mg/L) may indicate severe bacterial infection (Morgan, 2017). Management goals are to reestablish adequate perfusion and promote tissue oxygenation. Fluid resuscitation is necessary because women with sepsis are often hemodynamically unstable. The Surviving Sepsis Campaign guidelines call for an initial crystalloid bolus of 30 ml/kg per hour; however, during pregnancy and the early postpartum period, colloid osmotic pressure is normally decreased, and the risk for developing pulmonary edema secondary to fluid volume imbalance is increased. Damage to the pulmonary endothelium from exotoxins results in a further decrease in colloid osmotic pressure. The recommended fluid resuscitation bolus for pregnant women is 20 ml/kg/hour (Burke-Sosa, 2016). When a woman is hypovolemic, as occurs with severe sepsis, initiating vasopressor treatment before fluid resuscitation can exacerbate lactic acidosis and expedite end organ dysfunction (Vaught, 2018).

Women with septic shock may have decreased serum albumin levels as a consequence of capillary leak and may require albumin replacement. The GAS organisms use two powerful hemolysins with the potential to compromise red blood cell volume. Transfusion with packed red blood cells is recommended for hemoglobin levels of less than 7 g/dl (Plante, 2016). Platelet infusion may be needed if the platelet count is less than $10,000/\text{mm}^3$ (or less than $20,000/\text{mm}^3$ with bleeding risk). Disseminated intravascular coagulation is a sequela in women with sepsis that exacerbates hypoperfusion by occluding capillary circulation. Women with sepsis may require ventilatory support because increasing capillary permeability in the alveolar membrane impedes gas exchange, resulting in hypoxemia, with altered levels of consciousness affecting respiratory drive.

Individuals with severe sepsis will often manifest signs of metabolic and respiratory acidosis as physiologic compensatory mechanisms fail. Critical illness induces a condition known as *diabetes of stress*, triggering insulin resistance and hyperglycemia. High glucose levels are known to interfere with the immune response, decreasing the function of polymorphonuclear neutrophils (Remick, 2007). Although tight glycemic control is no longer the standard, some individuals may require insulin when two consecutive blood glucose readings are 180 mg/dl or greater (Kleinpell, Aitken, & Schorr, 2013).

Prophylaxis for venous thrombosis, particularly for pregnant women and those in the postpartum period, is recommended, by using low-molecular-weight heparin daily, in addition to pneumatic compression devices. Critically ill women are at risk for stress ulcers and may have increased risk for gastrointestinal bleeding, including coagulopathy, suggesting a need for prophylaxis with a proton pump inhibitor or a histamine blocker (Plante, 2016). Renal dysfunction is often present in women with sepsis, involving adrenal gland failure. Low-dose glucocorticoids may be needed as replacement treatment. Myocardial dysfunction is also common among women with sepsis; 60% of septic patients will have an ejection fraction of less

BOX 2 MULTIDISCIPLINARY TEAM STRATEGIES

Education
Simulations and drills
Debriefing after critical incident
Maternal morbidity/mortality review team
Combined nurse-physician unit and grand rounds and huddles

Source: Mann, Hollier, McKay, and Brown (2018).

than 45%, and additionally, proinflammatory cytokines may result in elevation of troponin levels in the bloodstream, potentially increasing mortality risk (Parfitt and Hering, 2018). These women may require dobutamine infusion, along with vasopressors to treat ongoing hypoperfusion with low cardiac output (Kleinpell, Aitken, & Schorr, 2013; Mazzeffi & Chen, 2010). IV human immunoglobulin therapy has been used successfully for the treatment of patients with certain immunodeficiency diseases. There is some evidence in the literature that IV immunoglobulin could improve outcomes for women with streptococcal toxic shock syndrome, possibly by diminishing virulence action (Wong & Stevens, 2013). IV immunoglobulin may reduce adhesive activity, decrease proinflammatory cytokines, and stimulate anti-inflammatory cytokine release (Shah, Vakili, & Kabakov, 2015).

Collaboration with infectious disease specialists and infection control nurses is essential to reduce the threat of GAS outbreaks in maternity units. GAS can spread rapidly between health care providers and women by direct contact with nasal or pharyngeal secretions or through contact with infected wounds or lochia, necessitating isolation and infection control measures. A woman with the infection should be isolated in a single room, and staff should use gloves and gowns when in contact infected individuals.

Rising to the Challenge

Although not as common as Group B *Streptococcus*, GAS poses a threat for women during pregnancy and the postpartum period. Prevention of maternal mortality and severe maternal morbidity is challenging, but nurses are in a position to influence outcomes and address gaps in care. Management of pregnancy-associated sepsis requires a multidisciplinary focus, with nurses, physicians, and other clinicians working as a team to develop systems for quality improvement (see Box 2). Hirshberg and Srinivas (2017) outlined tactics to reduce maternal morbidity and mortality. Among these strategies is the implementation of a multidisciplinary committee to investigate maternal morbidity and mortality. Data are collected with a maternal morbidity review tool and analyzed to isolate potentially preventable cases of morbidity and mortality and examine opportunities for improvement

BOX 3 COMPONENTS OF SEPSIS RAPID RESPONSE

Situation-Background-Assessment-Recommendation (SBAR) report to team
Evaluate respiratory status, assess need for ventilatory support
Place pulse oximeter
Oxygen as indicated via non-rebreather mask
Blood gases as indicated
Evaluate circulatory status and perfusion
Cardiac monitor
Blood pressure monitoring (manual preferred)
Assess capillary refill
IV access and IV fluid bolus (establish two sites in case needed for transfusion and medication)
Laboratory studies with IV start (complete blood count, platelets, coagulation panel, serum lactate, C-reactive protein, metabolic profile, liver function studies)
Obtain blood cultures per protocol (and other cultures as indicated, depending on suspected source)
Pharmacist to facilitate antibiotic orders
Foley catheter to monitor urine output
Sequential compression device applied
Ongoing reassurance for the woman and her family, keep significant other and family informed
Newborn to safe care situation, if applicable
Left tilt and continuous fetal monitoring, if pregnant
Arrange for and coordinate transfer to higher level of care as appropriate
Continue to communicate with the woman and family as appropriate

Note. IV = intravenous.

Sources: Burke-Sosa (2016); Parfitt and Hering (2018); Peel (2008); Vaughn and Parry (2016b).

(Hirshberg & Srinivas, 2017). Hospitals with residency training programs need to develop initiatives that facilitate stronger collaboration with nurses and other health care professionals to provide care that is coordinated and woman centered, such as combined nursing/physician unit rounds and multidisciplinary grand rounds. Implementing multidisciplinary staff meetings or huddles for the purpose of risk assessment can contribute to improved perinatal outcomes because caregivers can then function as a team to meet the needs of these greater-risk, more complicated patients (Mann, Hollier, McKay, & Brown, 2018).

Education is key to reducing sepsis-related morbidity and mortality. Many institutions use rapid response teams to intervene in situations in which an individual's condition deteriorates (see Box 3). Some facilities have perinatal-specific response teams and codes. Members of rapid response teams

need ongoing training to function efficiently and identify priorities in a variety of clinical scenarios. A rapid response nurse role can be designated, and this person would be available (by cell phone or pager) to consult with and support staff in caring for an at-risk perinatal population. Schorr (2018) suggests other roles for nursing that would support sepsis quality initiatives and describes a sepsis response team composed of providers who are skilled at managing severe sepsis. A sepsis coordinator can function as an educator, data collector, and sepsis care team leader (Schorr, 2018).

The Alliance for Innovation on Maternal Health, in collaboration with women's health care organizations, has developed practice guidelines, or bundles, with the primary goal of improving maternal safety. The application of these bundles encompasses a four-stage process of readiness, recognition, response, and reporting. Mann, Hollier, McKay, and Brown (2018) called attention to the fact that 50% of U.S. hospitals have three or fewer births daily, creating the possibility that staff are seldom exposed to maternal complications that occur less commonly, yet these facilities and staff need to identify women at risk and be prepared to react in effective and organized manner. Many hospitals focus on training and specialization of staff for the labor and delivery unit; however, most maternal deaths occur after birth. The Centers for Disease Control and Prevention's definition of *pregnancy-related death* encompasses women dying from pregnancy-related conditions not only during pregnancy but within 1 year postpartum. Developing and retaining a skilled, dedicated, and competent postpartum staff who function as a team with labor and delivery nurses needs to become a priority for health care facilities. Continuity of care after birth and during the intrapartum period in the community and outpatient settings, especially for women with comorbidities and pregnancy-related complications, should be a national priority. Emergency department staff also need ongoing training and skill development to meet the needs of women presenting with postpartum complications.

Conclusion

Infection is a significant contributor to maternal morbidity and mortality. Increasingly virulent strains of GAS have emerged over the past two decades. The goals in treating sepsis and septic shock are early recognition and aggressive intervention to reduce the risk of complications and mortality. The challenge remains to reduce rates of maternal morbidity and mortality caused by GAS-associated sepsis and toxic shock syndrome and to keep this wolf at bay. **NWH**



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