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Knowledge of the signs and symptoms of SIRS, sepsis, and septic shock is key to early recognition.

The role of the nurse

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Surviving sepsis:

HE APPENDECTOMY IS HEALING, though Mr. Green still feels weak from the emergency procedure after his appendix ruptured. At 70 years old, he thought he was in good shape and was managing his hypertension and type 2 diabetes. But today, two days after the operation, he feels a little restless as the nurse records his vital signs. She notes her patient's temperature is 100.6°F, heart rate 98 beats per minute, respiratory rate 22 breaths per minute, and blood pressure 102/76 mm Hg. His oxygen saturation is 95% on room air, and his weight is stable at 180 lb. Although the physical assessment is normal, something tells the nurse his status is deteriorating. The nurse reviews the chart to check his baseline vital signs and notes that his temperature and heart rate are elevated, while his blood pressure and oxygen saturation are lower, compared with the previous day.
Patients who have a ruptured appendix risk developing sepsis because pus leaks into the peritoneal space. Mr. Green is at even higher risk, however, because of his advanced age and chronic illness. Not wanting to wait any longer, the nurse calls the surgeon to update him on the patient’s condition.

**WHAT IS SEPSIS?** Sepsis is an infection of the bloodstream. In the US, there are more than 750,000 new cases of sepsis each year, and the incidence is increasing annually. The infection tends to spread quickly and often is difficult to recognize. The mortality rate associated with severe sepsis remains unacceptably high—approximately 28% to 50%. These percentages increase with the number of organs affected by the infection, with mortality rates reaching 75% to 85% when four or more organs fail.

Nurses in a variety of settings, from long-term care facilities to open-heart cardiac-care units, will care for patients with severe sepsis. As nurses, we are in a unique position to identify patients at the earliest signs of sepsis and to prevent the spread of severe infection. Early recognition allows for appropriate treatment to begin sooner, decreasing the likelihood of septic shock and the associated cascade of life-threatening organ failure.

Anyone with an infection may be at risk for developing sepsis, but certain factors may increase this risk. The most vulnerable populations are the elderly and newborns; people with chronic illnesses such as diabetes or cancer; those who are immunocompromised, such as after organ transplant, splenectomy, or those with HIV or AIDS; people receiving immunosuppressive therapy, such as chemotherapy; and malnourished and debilitated patients.

**PATHOPHYSIOLOGY** In order to understand the body’s response to sepsis, we must first review the pathophysiology. Sepsis is a complex process; it is the body’s systemic response to an infection. When the body is unable to contain a localized infection at its source, the infecting organism leaks into the bloodstream, causing sepsis. This is associated with inflammation, coagulopathy, and the maldistribution of blood flow.

When the invading organism, or antigen, enters the bloodstream, it releases endotoxin, a toxic substance usually associated with gram-negative bacteria. In response, the body’s immune system releases proinflammatory mediators, such as prostaglandins and cytokines, including tumor necrosis factor and interleukins, into circulation. Cytokines are immunomodulators released by white blood cells in response to the endotoxins, and together they are responsible for causing vasodilatation, increased capillary permeability, and increased coagulation. In a healthy person under normal circumstances, the body can control these processes and heal; but in the septic patient, the endotoxins stimulate the release of too much of the immunomodulators, causing an exaggerated, excessive response.

Vasodilatation is the body’s way of increasing blood flow to the affected area, thereby transporting more white blood cells, such as macrophages, to control the original infection. However, vasodilatation, without a proportionate increase in blood volume, leads to hypotension. Increased capillary permeability allows fluid to leak out of the bloodstream and into surrounding tissue, causing edema. This further reduces blood pressure. Concurrently, fibrinolysis is impaired leading to a decrease in clot breakdown. This is thought to be the body’s attempt at confining the antigen. However, the formation of fibrin clots leads to microthrombi, causing hypoperfusion of tissues, tissue necrosis, and eventually organ failure.

**TERMS** Although the word “sepsis” is widely used among nurses, it is an extremely complex disease with specific diagnostic criteria. These criteria were established in 1991, and revisited again in 2001 at the International Sepsis Definitions Conference, a meeting of intensive care experts from around the world. Awareness of severe sepsis is low; many septic patients
are under-diagnosed at an early stage when aggressive treatment could still reverse the course of the infection. Part of the early identification of the septic patient is understanding the accepted definitions and criteria for diagnosing the condition.

Sepsis typically begins with the *systemic inflammatory response syndrome (SIRS)*, the body's response to an insult that results in the activation of the immune response. This inflammatory response is the body's way of attempting to maintain homeostasis. While infection is one trigger for SIRS, there are also noninfectious causes, including trauma, burns, myocardial infarction, or inflammatory processes such as pancreatitis. Therefore, it is possible for your patient to have SIRS without being septic. SIRS is diagnosed when the patient has two or more of the following signs and symptoms:

- Body temperature less than 96.8°F (36°C) or above 100.4°F (38°C)
- Heart rate greater than 90 beats per minute
- Hyperventilation (respiratory rate greater than 20 breaths per minute)
- PaCO\(_2\), less than 32 mm Hg (normal 35 to 45 mm Hg)
- White blood cell count greater than 12,000/mm\(^3\) or less than 4,000/mm\(^3\) (normal 5,000 to 10,000/mm\(^3\))

**Sepsis** is present when a patient has SIRS plus a documented infection. This infection can be caused by bacteria, viruses, or fungi. **Severe sepsis** is defined as sepsis complicated by organ dysfunction, hypotension, or poor perfusion, and is considered the most common cause of death in non-coronary critical care units. Signs of organ dysfunction include:

- Altered mental status
- Acute oliguria (urine output less than 0.5 mL/kg/h)
- Hyperglycemia in the absence of diabetes
- Hypoxemia
- Coagulopathy (international normalizing ratio (INR) greater than 1.5)
- Gastric ileus

Hypotension is when the patient's systolic blood pressure is less than 90 mm Hg or mean arterial pressure (MAP) is less than 60 mm Hg. Poor tissue perfusion is evidenced by an increased serum lactate level or slow capillary refill. Lactic acid is produced as an end product when tissues do not receive adequate oxygen, resulting in anaerobic metabolism. Therefore, a serum lactate level greater than 2 mmol/L is an indicator of hypoperfusion and organ dysfunction. Capillary refill is checked by applying pressure to the patient's nail bed, causing it to blanch, and then letting go, counting the seconds until the nail bed turns pink again. Normal capillary refill is less than two seconds.

**Septic shock** is characterized by persistent hypotension that does not improve even after adequate fluid resuscitation. This is evidence of acute circulatory failure in the septic patient. Fluid resuscitation consists of colloids (albumin, packed red blood cells), crystalloids (normal saline, lactated ringers), or both. A fluid challenge may be ordered by the physician if hypovolemia is suspected. This usually consists of 500 mL to 1,000 mL of crystalloids or 300 mL to 500 mL of colloids infused over 30 minutes. At the end of the infusion, the nurse should reassess the patient and note any improvement in blood pressure or urine output. Because such a large amount of fluid is infused over a short period of time, the nurse should carefully monitor the patient for signs of pulmonary edema, including decreased oxygen saturation and crackles in the lungs.

It is important to note that hypotension in infants and children is a late sign of septic shock and therefore should not be used as an indicator of severe sepsis. Because children maintain a higher vascular tone than adults, blood pressure does not decrease until the child is no longer able to compensate.

Looking back at Mr. Green's vital signs, we see that he meets the criteria for SIRS (elevated temperature, pulse, and respiratory rate). Because of his admitting diagnosis of ruptured appendix, we can presume he has an infection, fulfilling the criteria for sepsis. In addition, the nurse had noted the patient was restless, which may be an early indicator of altered mental status and deteriorating condition. His physician orders blood work, including a complete blood count with differential, complete metabolic panel, arterial blood gas (ABG), serum lactate, prothrombin, and partial thromboplastin times, and transfers Mr. Green to the intensive care unit (ICU) for further workup.

**MANAGING THE SEPTIC PATIENT** In 2003, representatives from 11 international organizations came together in an effort to increase awareness and improve outcomes for patients in severe sepsis. This meeting, known as the Surviving Sepsis Campaign, produced key recommendations based upon evidence-based practice for resuscitating the septic patient during the first six hours after recognition of the diagnosis.
In Mr. Green's case, the ICU nurse establishes vascular access to initiate aggressive fluid resuscitation. Because the patient arrives with a large bore IV in his arm, this site is used to infuse normal saline. Goals of this initial fluid resuscitation include increasing the patient's blood pressure to a MAP greater than 65 mm Hg and urine output more than 0.5 mL/kg/h. In order to more closely monitor Mr. Green's urine output, the nurse inserts a Foley catheter with urimeter so that hourly measurements may be recorded. Another goal is to maintain a central venous pressure (CVP) of 8 mm Hg to 12 mm Hg, which can be monitored by central IV access. CVP is a measurement of the pressure of blood entering the right side of the heart and is a close estimate of right atrial pressure. The benefits of central IV access include having multiple ports through which to infuse fluids and medications, infusion of vasopressors that can be irritating to peripheral veins, and the ability to draw blood samples rather than sticking the patient for venipuncture.
Blood cultures also are ordered to identify the cause of infection. Cultures should be drawn before starting antimicrobial therapy in order to most closely identify the organism causing the sepsis. The administration of antibiotics prior to drawing the blood cultures may affect the growth of any pathogen and prevent a positive culture. At least two separate cultures should be obtained from two different sites, with at least one drawn peripherally. When possible, a culture also should be drawn from the IV site to determine if the infection is catheter-related. Once the cultures are drawn and new vascular access is obtained, the old IV access should be promptly removed.

Next, IV antibiotics should be administered promptly to improve the odds of survival. According to the guidelines, antibiotics should be administered within the first hour of the diagnosis of severe sepsis. The choice of initial empiric antibiotics should be broad enough to cover the likely cause of the infection, and usually includes more than one type of antibiotic. Once results of the cultures are known, the antibiotics may be changed to a narrower spectrum to avoid risking the development of a secondary infection with resistant pathogens.

A DOWNWARD SPIRAL Two hours after arriving in the ICU, Mr. Green's blood pressure is 88/40 mm Hg with a MAP of 56 mm Hg even after the administration of four liters of normal saline boluses. Further assessment reveals hypoactive bowel sounds and cool, clammy skin. His urine output for the past two hours has been only 40 mL. Blood work reveals that his white blood cell count increased from 12,000/mm³ to 30,000/mm³, and that he has elevated BUN and creatinine, elevated liver function tests, and an INR of 3.5, which reflect renal and liver dysfunction. His worsening hypotension, combined with signs of organ dysfunction, indicate that the patient is now in septic shock.

Following unit protocol, a norepinephrine (Levophed) infusion is started through the central IV catheter. Because Mr. Green's blood pressure has not improved after adequate fluid resuscitation, guidelines state that therapy with a vasopressor should be initiated in order to achieve minimal perfusion pressure.

Norepinephrine is a potent vasoconstrictor and increases blood pressure without too much change in heart rate. The goal is to maintain his MAP above 65 mm Hg, and the nurse titrates the infusion as needed. With increased perfusion to the kidneys, his urine output should also improve with a goal of greater than 0.5 mL/kg/h. Now that Mr. Green requires vasopressor therapy, an arterial line is inserted by the unit physician into the patient's radial artery in order to closely monitor his blood pressure.

Vasopressin (Pitressin) is another vasoconstrictor that is commonly used, often in conjunction with norepinephrine, to maintain adequate perfusion pressure. Doses of vasopressin should not exceed 0.04 units/min, as this has been associated with myocardial ischemia and cardiac arrest. The guidelines also suggest the addition of an inotrope, or medication that increases the force of the heart's contraction, in order to increase cardiac output and improve tissue perfusion. Dobutamine (Dobutrex) is the first-choice inotrope for patients with low cardiac output that does not improve with fluid resuscitation.

Four hours after Mr. Green's admission into the ICU, the nurse notices that he is becoming more restless and his breathing appears labored at 34 breaths/min. His oxygen saturation...
now is only 89% on supplemental oxygen. Upon auscultation, the nurse notes crackles in his lungs to both lower lobes. An ABG reveals pH 7.26 (normal 7.35 to 7.45), PaCO₂ at 51 mm Hg (normal 35 mm Hg to 45 mm Hg), PaO₂ at 60 mm Hg (normal 80 mm Hg to 100 mm Hg) and HCO₃ at 24 mEq/L (normal 22 mEq/L to 28 mEq/L), indicating respiratory acidosis and hypoxemia. In addition, his serum lactate is 4.5 mmol/L.

As the downward spiral of septic shock progresses, the capillary permeability continues to increase, which interferes with gas exchange across the alveolar-capillary membrane. Mr. Green is intubated and placed on mechanical ventilation to facilitate oxygen delivery and reduce the work of breathing. The nurse starts an IV infusion of midazolam (Versed) and fentanyl (Sublimaze) to keep the patient comfortable. Other nursing interventions include care of the endotracheal tube to maintain patency and suction as needed, oral care with chlorhexidine rinse, and maintaining the head of the bed at 45 degrees, which has been shown to reduce the incidence of ventilator-acquired pneumonia.

After the initial stabilization of the patient, ICU nurses continue to monitor the patient’s condition carefully, recording vital signs on an hourly basis, measuring intake and output, titrating his drips, and administering his medications as ordered. After consulting with the nutritionist, the physician orders continuous total parenteral nutrition (TPN) until the patient’s bowels become functional again.

A continuous infusion of insulin also is started to maintain blood glucose values less than 150 mg/dL, which has been shown to significantly improve survival in surgical patients. The nurse monitors Mr. Green’s blood sugars hourly until stable, and then on a regular basis, at least every four hours. Because the need for vasopressor therapy indicates adrenal insufficiency, the patient is given IV hydrocortisone (A-Hydrocort, Solu-Cortef). This also has been shown to reduce mortality rates in patients in septic shock.

One of the last treatment options for patients considered at high risk for sepsis-related death is therapy with drotrecogin alfa (activated) (Xigris). This is a recombinant form of human-activated protein C, or rhAPC, a naturally occurring protein made by the body with both anticoagulant and anti-inflammatory properties.

As sepsis progresses, levels of activated protein C decrease in the body, leading to increased clotting and therefore worsening tissue ischemia. The rhAPC has been shown to improve survival in patients with sepsis-induced organ dysfunction, and guidelines state it should be given as soon as possible once the patient is identified as having at high risk of death. Because drotrecogin alfa (activated) may potentially increase the risk of bleeding, it may be contraindicated in some patients, and the risks and benefits should be weighed for each individual patient.

**POSITIVE OUTCOME**

As a last resort, Mr. Green is started on drotrecogin alfa (activated). Eight hours later, his vital signs and lab values begin to improve. His elevated white blood cell count begins to come down, and liver and renal function tests also begin to trend down. Urine output also improves. Over the next several days, he is able to be weaned off vasopressors and continues to maintain adequate blood pressure. After a spontaneous breathing trial, Mr. Green is extubated and placed on a nasal cannula for oxygen delivery. As his bowel function returns, he is started on enteral nutrition and begins to regain his strength. Four days later, he is transferred out of the ICU and back to the medical/surgical unit, where he continues to make progress before being discharged home.

This success story might not have been possible without the sharp assessment skills of Mr. Green’s nurses. One of our roles as a nurse is that of patient advocate, and as such we are closest to the patient, placing us in a key position to identify any subtle changes at their earliest onset. Knowledge of the signs and symptoms of SIRS, sepsis, and septic shock is key to this early recognition. Once sepsis is diagnosed, early and aggressive treatment in accordance with the Surviving Sepsis Campaign guidelines can begin, which greatly reduces mortality rates associated with sepsis.

References


