Assessing & Managing Sepsis in the Prehospital Setting

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Part one of this article, “Infection Detection: Identifying & understanding sepsis in the prehospital setting,” published in the January issue, was a general overview of sepsis along with scene size-up and patient evaluation. This article focuses on prehospital assessment and screening tools, prehospital and interfacility management of sepsis patients, and following the patient from ED to discharge.
The prehospital assessment focuses on vital sign assessments and use of end-tidal carbon dioxide (EtCO2) and serum lactate monitoring to defeat sepsis in the field. Prehospital management focuses on fluid resuscitation and vasopressor infusions with the goal of improving the patient’s perfusion status.

Prehospital Sepsis Screening Tools
The American College of Chest Physicians/Society of Critical Care Medicine’s definition of sepsis (included in part one) contains very thorough and sensitive tools to assist clinicians in its identification. However, in most EMS systems, the inclusion of lab values and arterial blood gases aren’t feasible.

Instead, providers use the Robson screening tool and the BAS 90-30-90 scales, which have been incorporated into prehospital systems internationally. Both of these scales refer to the clinical signs in a patient suspected of having an active infection.

The Robson screening tool consists of two parts to help identify and isolate those patients with septic shock so prehospital management can be initiated. With this tool, a patient is considered septic if any two of the following conditions are met:

1. Temperature > 38.3 degrees C (100.9 degrees F) or < 36.0 degrees C (96.8 degrees F);
2. Heart rate > 90 Beats per minute;
3. Respiratory rate > 20 Breaths per minute;
4. Acutely altered mental status; or
5. Serum glucose < 120 mg/dL or 6.6 mmol/L.

The BAS 90-30-90 scale is a Swedish model that utilizes an objective approach for evaluating potentially septic patients. With this method, a patient is considered to be septic if one or more of the criteria is met:

1. Systolic blood pressure <90;
2. Respiratory rate > 30 breaths per minute; or
3. Oxygen saturation < 90%.

Current research suggests the Robson screening tool is more likely to
identify septic patients in the field, but many prehospital protocols in the United States utilize a combination of the two scales to evaluate perfusion status and potential for infection. For example, the Central Ohio Trauma System’s white paper includes evaluation criteria for EMS providers. Providers in this system utilize a sepsis alert protocol, referred to as “Code Sepsis” in some parts of the country, to decrease the door-to-early-goal-directed therapy. The criteria to activate a sepsis alert is a suspected infection with a systolic blood pressure < 90 mmHg or two or more of the following criteria:

1. Heart rate > 90 beats per minute;
2. Temperature < 96.8 degrees F or > 100 degrees F;
3. Respiratory rate > 20 breaths per minute;
4. Acute altered mental status; or
5. Increased serum lactate levels (> 4 mmol/L);

Prehospital diagnostics tools include the use of portable fingerstick lactic acid meters, EtCO2 measured with capnography, and ultrasound. Use of capnography is commonplace in many U.S. services, while lactate meters and ultrasound are rather rare.

**Capnography**

Capnography, a well-known tool in EMS, provides valuable information not only about ventilation but perfusion as well. As long as the body is metabolizing glucose and oxygen, waste products will be eliminated into the bloodstream. They can only be released into the alveolus if there’s normal perfusion of the lung with blood.

As perfusion decreases, so does the EtCO2. This results in elevation of the metabolic waste, which is comprised mainly of lactic acid. Therefore, EtCO2 level is inversely proportional to lactate levels. As we see lactate levels rise in septic patients, we see EtCO2 levels drop. EtCO2 readings of less than 25 mmHg in the clinical setting of shock are associated with significant increase in mortality. Patients with EtCO2 of 25 mmHg may have lactate levels as high as 6.1 mmol/L. Capnography can be monitored and helpful in assessing the impact of therapies designed to improve perfusion.
This method of sepsis detection, however, is being underused. In a survey with 39 responses from U.S. Metropolitan Medical Directors, AKA the Eagles Coalition, performed by Ryan Gerecht, MD, CMTE, it was found that only four of the represented EMS systems have a dedicated sepsis protocol, with one system currently developing a procedure and another considering the implementation of a dedicated sepsis protocol. In addition, only one system measures lactate levels and only one uses EtCO2 surrogate for sepsis detection. For more information on how capnography is being used effectively in Orange County, Fla., for sepsis detection, see “Utilizing Capnography in Sepsis” on page 38.

**Volume Status & Resuscitation**

The solution to the pollution is dilution. OK, it’s not the solution, but it’s the beginning of our treatment. As the cytokine (proteins important in cell signaling) levels increase, the immune response causes massive vasodilation as well as a decreased systemic vascular resistance, resulting in hypotension.

The goal of the fluid resuscitation is to get enough fluid in the vasculature to increase the blood pressure enough to perfuse the vital organs. It’s important to remember that unlike hypovolemic shock, septic shock doesn’t need more oxygen-carrying fluid. Isotonic fluids are adequate, especially in the initial phases of treatment, for increasing the blood pressure.

In the prehospital setting, we’re limited to the available tools for evaluating the effectiveness of the fluid resuscitation efforts. Generally, we administer 500 mL boluses until we have a systolic blood pressure greater than 90. More importantly, paramedics should focus on the mean arterial pressure. An eager paramedic could perform the formula MAP = DP + 1/3 PP, where MAP is the mean arterial pressure, DP is the diastolic pressure and PP is pulse pressure. Alternatively, most automated blood pressure cuffs provide a MAP along with the blood pressure. MAPs are a better representation of overall perfusion to the vital organs of the body.

**Serum Lactate**

Trending fingerstick lactate acid levels can be useful if time permits and the equipment is available. When measured, the goal is to get the lactate levels below 2 mmol/L. Even if trending is unreasonable due to transport time, an
initial lactate level is useful for the ED to demonstrate what level the patient was at prior to fluid resuscitation.

Fingerstick lactate monitors are sold to athletes to measure the efficiency of their training and there’s data to support the accuracy of these devices—but their use in EMS and the medical setting is not FDA-cleared. “Off-label” use of these commercial lactate monitors by EMS would require medical director and state EMS office approval. As of now, there’s no FDA-cleared device that is affordable to most EMS agencies, as even the uncleared devices range in price from $200 to $400.

**Ultrasound & Central Venous Pressures**

Another popular method for measuring fluid status and fluid resuscitation in the ED and critical care setting is ultrasound. Ultrasound use is gaining ground in the prehospital setting. If the inferior vena cava has a 50% or more reduction on inspiration, fluid resuscitation is needed. If available, the provider could administer 20 cc/kg boluses every 20 minutes, titrating to a vena cava collapse of less than 50%.

While EtCO2 can evaluate perfusion, ultrasound can provide valuable information regarding fluid status. Providers can measure the diameter of the inferior vena cava (IVC) to evaluate if fluid resuscitation is necessary. If there’s a 50% or greater decrease in the diameter of the IVC on inspiration, the patient has poor perfusion.

In the critical care and interfacility realm, some patients may have a central line or pulmonary artery catheter in place. If a central line is available, the central venous pressure will be less than 2 mmHg. If a pulmonary artery catheter, commonly referred to by the trade name Swanz-Ganz catheter, is in place, then you’ll see a right atrial pressure less than 2 mmHg, pulmonary capillary wedge pressure less than 2 mmHg, a pulmonary artery systolic less than 20 mmHg, and a pulmonary artery diastolic less than 10 mmHg.

Although this is more common in critical care transport by air medical or ground critical care and transport teams, in some rural areas paramedics may end up transporting patients with these lines from smaller ICUs to larger hospitals with more capabilities.
Case Study
On arrival at the ED, the patient continues to have an altered level of consciousness. The ED continues fluid resuscitation and draws labs for the patient. The patient’s lactate is 4.2, white blood cell count is 22,000, and his neutrophils are 18,000.

After aggressive fluid resuscitation, the ED staff begins a dopamine drip of 5 mcg/kg/min. They monitor the patient’s blood pressure and mental status while gradually increasing the dopamine. At 15 mcg/kg/min, the patient becomes more coherent and is eventually able to answer questions.

The patient informs the ED staff he’s been having abdominal pain for the past two or three days and has been constipated for the last week. He had an appointment scheduled with his primary care physician for this afternoon. The ED staff performs a CT scan that reveals a bowel obstruction. Arrangements are made to transfer the patient to a regional medical center.

Interfacility Infusions in Septic Shock
Paramedics often question when it’s appropriate to initiate vasopressors. If the patient isn’t responding to aggressive fluid resuscitation, paramedic protocols generally recommend vasopressors be used. If the patient has received 20–30 mL/kg of saline and hasn’t improved, then dopamine is indicated. The paramedic should start at 5 mcg/kg/min and shouldn’t exceed 20 mcg/kg/min.

Dopamine increases the patient’s heart rate and stroke volume, which increases the cardiac output and the MAP. As the MAP improves, the patient may become more coherent and capable of answering questions. Paramedics should be familiar with how dopamine works so they can be prepared for the potential tachydysrhythmias that may present.

The vasopressor of choice in septic shock is norepinephrine (brand name Levophed). Norepinephrine works primarily by vasoconstriction with less side effects on the heart compared to dopamine. It acts as an alpha and beta-1 agonist.

The dose will be 2–12 mcg/min, and may be as high as 1.5 mcg/kg/min.
Depending on your protocols or written orders, you may be able to increase the infusion during an interfacility transport by 1–2 mcg/min titrating to a MAP of 65.

According to the 2012 Surviving Sepsis guidelines, vasopressin may be added to norepinephrine treatment at 0.03 units/minute. The goal of utilizing vasopressin is to increase the MAP to 65.

Providers may also see epinephrine infusions from 1–10 mcg/min, which increases the MAP by increasing the stroke volume and cardiac index.

Epinephrine may be used with or in place of norepinephrine. However, providers should be aware that epinephrine infusions may stimulate skeletal muscle aerobic metabolism, potentially increasing lactate levels and interfering with the use of lactate as a marker.

If myocardial dysfunction is suspected along with sepsis, patients may have a dobutamine infusion instead of dopamine. The advantage of dobutamine over dopamine is that it works by increasing myocardial contractility without increasing the heart rate.

Dobutamine may be administered at 2–20 mcg/kg/min titrated to MAP, which correlates with an improving cardiac output. Dobutamine may be administered in combination with norepinephrine to increase cardiac output and peripheral vascular resistance.

Antimicrobial infusions within one hour of arrival is a target for septic patients. Depending on the antimicrobial, the infusion may have completed prior to the interfacility transport. However, if it hasn't, providers may end up transporting the antimicrobial infusion.

If the infusion was recently initiated, providers should evaluate for signs of an allergic reaction and be prepared to terminate the infusion if necessary.

**Case Study Continued**
The EMS crew arrives at the hospital to pick up the patient and transport him to a regional hospital with ICU capabilities, approximately one hour away. At this point, the patient’s dopamine is at 20 mcg/kg/min and a norepinephrine infusion is initiated at 5 mcg/min. The crew packages the
patient, sets up the infusion pump onto the stretcher and transports the patient to the ambulance.

En route to the regional hospital, the patient becomes less responsive. The paramedic elects to increase the norepinephrine infusion to 7 mcg/min. The patient’s ventilation rate drops to 10 breaths per minute. The patient has no gag reflex and the paramedic successfully intubates the patient with a 7.5 endotracheal tube and ventilates at a rate of 12 beats per minute. His radial pulses are absent and the carotid pulses are weak. The crew’s automated noninvasive blood pressure is unable to obtain a blood pressure.

A crew member calls the hospital and informs of the patient’s decline. On arrival, they bypass registration and go directly to the ICU. The crew moves the patient to the hospital bed and gives a verbal report. A respiratory therapist connects the patient to the vent and the nurses change out the patients IV tubing and begin their assessment.

From ED to Discharge
It’s important EMS providers understand not only their own care, but the entire process of healthcare that occurs from the time the patient calls 9-1-1 to the time the patient is discharged to their home. Septic patients are often critically ill, but the way their symptoms are described to a dispatcher may cause them to be dispatched as non-priority calls. Remember, even “general illness” or “sick patient” calls can become very serious very quickly.

In the prehospital setting, the septic patient should receive a thorough assessment, appropriate airway management, high-flow oxygen and fluid resuscitation. If the patient is hypotensive after being properly fluid resuscitated, the use of dopamine may be considered.

In the ED, fluid resuscitation will be continued and secondary vasopressors may be started. Blood cultures will be drawn, and if specific causes of sepsis are suspected, urine, stool, wound or other cultures may be obtained. IV antibiotics will be initiated. If the patient is in severe respiratory distress, advanced airway management, such as rapid sequence induction intubation, may be considered. Lab values, including blood counts and metabolic enzymes, will be monitored as well.
The patient will most likely be transferred from the ED to the ICU, where fluid resuscitation and vasopressor infusions will be continued. If one hasn’t already been inserted, a Foley catheter will be placed. Antibiotics may be changed once cultures and sensitivity tests have been completed, since some antibiotics are more appropriate for specific bacteria.

Lab values, particularly those indicative of organ function, will be monitored carefully. If the facility doesn’t have an ICU, the patient may be stabilized for transfer to a larger facility. If this is the case, the transferring paramedic should be aware of and familiar with the various vasopressors and antibiotics used by the smaller facilities within their service area. Also, vasopressors should generally be transported using an IV pump whenever possible to ensure accurate medication administration.

The ICU will also strive to correct the underlying cause of sepsis, which may involve surgical intervention (for abscesses or obstructions) or continued antibiotic treatments. Once the infection has been resolved, the ICU staff will begin to wean the patient off any vasopressors and the mechanical ventilator, if the patient was intubated. The patient will remain in the ICU until vital signs and lab values are stable and all critical interventions are stopped.

Many patients who stay in the ICU are transferred to either a medical/surgical unit or an ICU step-down unit. In these inpatient units, patients receive IV or oral antibiotics, oxygen and other respiratory therapies, and wound care monitored by the nursing staff. Once vital signs are completely stable, the patient is discharged to their home or an extended-care nursing facility.

Case Study Continued

In the ICU, the staff is able to stabilize the patient’s blood pressure with the norepinephrine infusion. He’s scheduled for surgery to have the bowel obstruction removed. Antibiotics are initiated. He’s weaned off the ventilator with supplemental oxygen still utilized on day four, weaned off of vasopressors at day seven, and transferred to a medical/surgical unit on day eight.

In the medical/surgical unit, antibiotics are continued by mouth. The patient
is on a nasal cannula for two more days. He completes his course of antibiotics and remains hemodynamically stable. He’s discharged from the hospital on day 12.

**Conclusion**
Good prehospital management can make a profound difference in a septic patient’s outcome. Early identification and treatment can significantly decrease patients ICU stays, hospital stays and mortality.

EMS no longer ends in the prehospital arena. As our industry grows, paramedics are expected to transport complex infusions, ventilators and advanced diagnostic equipment. Interfacility transports can at times be seen as challenging or more challenging than prehospital runs. Septic patients in particular can be quite challenging to assess and manage in both the prehospital and interfacility arenas.

**Resources**

End-tidal carbon dioxide may be used in place of lactate to screen for severe sepsis

By Christopher Hunter, MD, Ph.D

Early identification of sepsis provides the best opportunity for aggressive goal-directed therapy that may improve survival. Screening tools, protocols and alert systems have been shown to improve guideline adherence for interventions such as antibiotics and fluid resuscitation. EMS personnel are caring for an increasing number of septic patients, and prehospital screening tools for severe sepsis have been developed to improve awareness.1

Most of these screening tools rely on the suspicion of infection, ≥ 2 systemic inflammatory response syndrome (SIRS) criteria, and point-of-care serum lactate levels. However, it’s possible to screen for severe sepsis without these costly devices and potentially time-consuming blood draws.

Capnography, the waveform measurement of exhaled end-tidal carbon dioxide (EtCO2), is a well-known tool in EMS. EtCO2 is a continuous variable determined by basal metabolic rate, cardiac output and ventilation. Thus, abnormal levels may reflect derangement in perfusion, metabolism or gas exchange. Capnography has multiple prehospital applications for confirmation and monitoring of proper endotracheal tube placement, and evaluating return of spontaneous circulation during cardiopulmonary arrest. However, it can be very effective when used on the conscious patient to detect conditions such as septic shock.

Severe sepsis is characterized by poor perfusion, leading to a buildup of serum lactate and resulting metabolic acidosis. EtCO2 levels decline in the setting of both poor perfusion and metabolic acidosis. To compensate for metabolic acidosis, patients increase their minute ventilation. This increased respiratory rate “blows off” carbon dioxide and lowers EtCO2. At the same time, poor tissue perfusion decreases the amount of blood flow
to the alveoli of the lungs, reducing the amount of carbon dioxide that can be exhaled—the most dramatic demonstration of this process is during cardiac arrest. Therefore, EtCO2 is inversely proportional to lactate: As lactate levels rise in septic patients, EtCO2 levels drop.

Previous studies have shown that low EtCO2 levels correlate with elevated lactate levels and predict mortality in patients with suspected sepsis, severe sepsis and septic shock. In fact, low prehospital EtCO2 levels predict metabolic acidosis and mortality across a wide spectrum of patient complaints.

In patients with ≥ 2 SIRS criteria, an EtCO2 measurement of ≤ 25 mmHg is strongly correlated with lactate levels > 4 mM/L and increased mortality. Capnography is fast, non-invasive and available on many ALS vehicles. An adequate screening for severe sepsis may be provided by utilizing capnography in addition to modified SIRS criteria in the setting of suspected infection. Furthermore, capnography can be monitored to assess the impact of therapies designed to improve perfusion.

The Orange County (Fla.) EMS System, with assistance from our regional hospitals, has developed a Sepsis Alert protocol utilizing low EtCO2 as an equivalent to elevated serum lactate. This has allowed our agency’s discretion to utilize their existing equipment rather than purchase approved lactate monitors. Prospective evaluation of this protocol is currently ongoing.

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References


Orange County EMS Sepsis Protocol

Sepsis is a rapidly progressing, life-threatening condition due to systemic infection. Sepsis must be recognized early and treated aggressively to prevent progression to shock and death. Sepsis can be identified when the following markers of the SIRS are present in a patient with suspected infection:

>> Temperature > 38 degrees C (100.4 degrees F) OR < 36 degrees C (96.8 degrees F);
>> Respiratory rate > 20 breaths per min; and
>> Heart rate > 90 beats per min.

In addition to physiologic markers of SIRS, severe sepsis may cause hypoxia and inadequate organ perfusion, resulting in metabolic acidosis marked by elevated blood lactate levels and decreased EtCO2 levels (measured by capnography).

Sepsis Alert

The purpose of a sepsis alert is to provide pre-arrival ED notification in order to facilitate rapid assessment and treatment of a suspected severe sepsis patient. A sepsis alert will be instituted for patients meeting the following three criteria:

1. Suspected infection;
2. Present with two or more markers of SIRS; and
3. EtCO2 ≤ 25 mmHg OR lactate > 4 mmol.
BLS Care
>> Supplemental 100% oxygen

ALS Care
>> Full ALS assessment and treatment
>> Notify hospital of incoming sepsis alert prior to arrival
>> IV 0.9% NaCl en route

- Administer 250 mL boluses until systolic BP > 90 mmHg
- Total amount of IVF should not exceed 2000 mL
- Boluses may be given in rapid succession if systolic remains < 90 mmHg

>> If systolic BP remains < 90 mmHg after 4th fluid bolus (1000 mL):

- Dopamine infusion at 5–20 mcg/kg/min titrated to maintain systolic BP > 90 mm Hg

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