

Septic Shock in the Operating Room

Arthur Atchabahian, M.D.

New York, New York

OBJECTIVES

1. Understand the pathophysiology of severe sepsis and septic shock and the implications for the management of anesthesia;
2. Know the therapies available to treat and support a patient in septic shock.

STEM CASE - KEY QUESTIONS

A 52-year-old woman with a history of intravenous drug abuse, infective endocarditis 3 years ago and peripheral vascular disease with lower extremity ulcers, is scheduled as an emergency case for right great toe amputation for gangrene, and left ankle incision and drainage for an infected ulcer.

You see her on a stretcher in the holding area. She looks pale and weak, is oriented to name and place but confused about the date. She complains of pain in the left leg. A few crackles are heard at the lung bases. The heart sounds are regular, with a II/VI diastolic murmur. A small quantity of concentrated urine is present in the urine bag. Her vital signs are HR 110/min, BP 110/70 mmHg, RR 32/min, temperature 38.8°C and SpO₂ 98% on 3 L/min of oxygen by nasal cannula.

There are no prior medical records, and her primary family physician is unavailable. The chest radiograph shows cardiomegaly and mild cephalization of the vascular markings. The EKG is unremarkable except for sinus tachycardia. The laboratory results are as follow:

WBC $16.8 \times 10^3/\mu\text{L}$; Hematocrit 32.2%; Platelets $127 \times 10^3/\mu\text{L}$; INR 1.69; PTT 41.4 sec; electrolytes are within normal limits; BUN 34 mg/dL; Creatinine 1.6 mg/dL.

1. Would you postpone this case to optimize the patient's status? Would you administer fluid, blood, or any medication?
2. What anesthetic technique would you use?

A transthoracic echocardiogram is performed, but imaging is of poor quality. It is read as showing grossly normal left ventricle size and function. Following the placement of an arterial line, general anesthesia is induced with ketamine and succinylcholine. Intubation is uneventful. Anesthesia is maintained with fentanyl as well as isoflurane in nitrous oxide and oxygen. Initially, the patient is stable, but she suddenly becomes hypotensive with a blood pressure of 70/40 mmHg, while the pulse saturation decreases to 88%.

3. How do you treat this episode?

After uneventful central venous catheterization, a pulmonary artery cannot be floated into the right ventricle. Several attempts are unsuccessful, and some runs of non-sustained ventricular tachycardia are seen. The central venous pressure is 18 mmHg.

4. What treatment would you administer at this point?

The surgeon announces that the infection that seemed localized to the ankle is actually tracking up the posterior compartment of the leg to the knee, with muscle necrosis and osteomyelitis, and that an above-knee amputation is necessary. This had not been discussed with the patient who only consented to the toe amputation and the ankle incision and drainage.

Meanwhile, a norepinephrine infusion has been started, but the mean arterial pressure remains around 60 mmHg.

5. Should the surgery proceed, or should consent be obtained from the family first?

6. What other therapies are to be considered?

You ask a colleague to perform a transesophageal echocardiogram. The left ventricle is normal in size, with an ejection fraction estimated to 60%. The right ventricle is dilated and a mild flattening of the interventricular septum is seen. Color Doppler evaluation shows moderate aortic insufficiency and mild tricuspid regurgitation.

The AKA is performed with minimal blood loss, and the patient is transported to the ICU intubated. Once in the ICU, the pulmonary artery catheter is floated into the pulmonary artery. The PA pressure is 65/32 mmHg, the PAOP is 16 mmHg, the CVP is 18 mmHg and the thermodilution cardiac output is 2.35 L/min.

7. What are the main aspects of therapy over the next few days? What is this patient's prognosis?

PROBLEM BASED LEARNING DISCUSSION

1. This patient is developing sepsis, and source control by surgical drainage of the infected ulcer is an essential part of the therapy. However, her surgical issue is not immediately life-threatening. Thus, her medical status (fluid status and tissue oxygen delivery) should be optimized prior to proceeding. Invasive monitoring can be discussed at this point, or an echocardiogram can be obtained. The algorithm described by Rivers et al. can be used to that effect, to optimize CVP, MAP and central venous saturation (or mixed venous saturation if a pulmonary artery catheter has been inserted). The algorithm (see figure) includes the use of fluid, blood, vasoactive medications (such as dopamine or norepinephrine) and inotropes (such as dobutamine).

After at least one set of blood cultures, appropriate antibiotherapy should be initiated. Antibiotic administration should not be delayed to obtain intraoperative cultures, since endocarditis prophylaxis is needed for this high-risk patient (history of endocarditis) undergoing septic surgery. Preoperative antibiotics will not interfere with pus culture, and it is essential to obtain bactericidal blood levels before incision to prevent further seeding.

2. Numerous options are possible. A regional technique has advantages such as absence of airway instrumentation and postoperative analgesia avoiding opioid administration. In this case, however, coagulopathy is present, hemodynamic stability is a major concern, and the sympathectomy induced by a central neuraxial technique might be difficult to compensate.

Bilateral peripheral nerve blocks are possible, but would be time-consuming, and in case of failure, general anesthesia will have to be used.

Assuming that no difficulty is expected in securing the airway, general anesthesia could be induced with etomidate, for hemodynamic stability. Adrenal suppression by etomidate might be of concern in a septic patient. Ketamine is also a possible choice. A technique associating intravenous fentanyl with nitrous oxide and low levels of isoflurane should also provide adequate operative conditions with the desired hemodynamic stability. The use of shorter-acting agents, such as remifentanyl and desflurane, to allow faster discontinuation in case of poor hemodynamic tolerance, can be discussed. A peripheral procedure such as the one planned here could be performed using ketamine as a main anesthetic.

3. Isoflurane administration should be discontinued to lighten the anesthesia level, and ventilation with 100% oxygen should be initiated.

The etiology of this episode should be determined to guide therapy. Septic shock with poor peripheral perfusion is likely but other causes, such as myocardial ischemia or hemorrhagic shock, are also possible. To make a diagnosis and guide further therapy, a pulmonary artery catheter should be inserted. Alternatively, a transesophageal echocardiogram can be performed. While providing more information and more reliable data than a pulmonary artery catheter, echocardiography has the disadvantage of being operator-dependent and of not being easily maintained in place to guide therapy postoperatively.

4. Central venous pressure is a poor marker of fluid status. There are no more elements to guide treatment than in the prior question. If the pulmonary artery catheter cannot be floated, therapies mentioned previously should be attempted, while efforts are made to obtain a transesophageal echocardiogram.

5. In this severely septic patient, protracted surgery and blood loss are extremely risky. Leaving the likely source of sepsis in place, however, will probably lead to further release of bacteria and cytokines in the bloodstream, making control of the septic syndrome unlikely. One could argue that the lack of consent, in the absence of clearly stated and witnessed refusal by the patient, should be overridden by medical necessity, and the potentially life-saving amputation should be performed.

6. In addition to catecholamines, vasodilatory shock due to sepsis responds well to low doses of vasopressin (2-6 units/hr IV), which also improve urine output. Low doses of steroids (hydrocortisone 50 mg IV q6h) should be considered to treat a relative adrenal insufficiency, and to reverse catecholamine resistance.

Source control and antibiotherapy are necessary. The only specific therapy for severe sepsis, activated protein C (drotrecogin alfa or Xigris®), cannot be used during surgery or within the first 12 hours after surgery because of the risk of bleeding. Once initiated, it can be discontinued 2 hours before invasive procedures or surgery.

7. Supportive therapy includes sedation, mechanical ventilation, fluid resuscitation, use of inotropes and/or vasoconstrictors guided by hemodynamics, renal replacement therapy if

necessary, trophic enteral feeding, tight glycemic control and administration of blood products. Low-dose steroids can be helpful in patients with relative adrenal insufficiency, especially when catecholamines are ineffective.

Specific therapies for severe sepsis are limited to source control, antimicrobial therapy and intravenous activated protein C. If gangrene due to anaerobes (*Clostridium perfringens*) is suspected, hyperbaric oxygen therapy should be discussed. If the surgical findings are suggestive of necrotizing fasciitis, IVIG should be considered, although efficacy remains controversial.

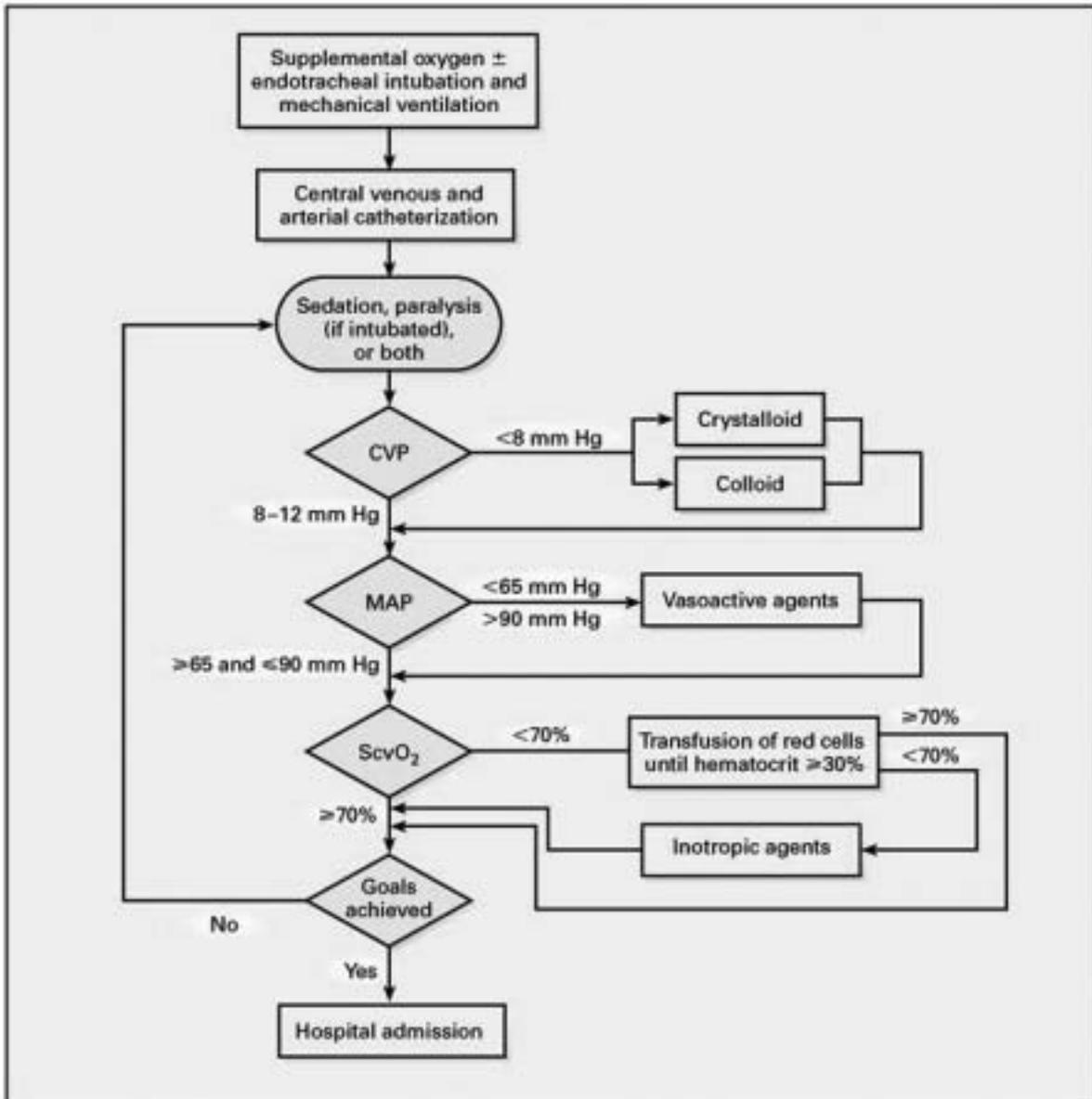
This patient has severe pulmonary hypertension with right ventricular failure. “Inodilators” such as milrinone can improve right ventricle contractility and decrease pulmonary artery resistance. Inhaled nitric oxide and prostacyclin are specific pulmonary vasodilators that can markedly improve right ventricular function.

The moderate aortic insufficiency in a patient with sepsis and a history of bacterial endocarditis is suggestive of recurrent endocarditis. A repeat TEE should be performed to identify signs of endocarditis, and surgical repair should be considered if medical treatment fails to stabilize the patient.

This patient’s prognosis is poor, with a probability of death exceeding 50%. Survival is even less likely if there indeed is aortic valve endocarditis.

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LEARNING SUMMARY

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