

Using continuous SvO₂ to assess oxygen supply/demand balance in the critically ill patient

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PURPOSE

Patients in critical care are often monitored to alert caregivers to threats of hemodynamic stability (as measured by blood pressure, cardiac output, pulmonary capillary wedge pressure, central venous pressure, and systemic vascular resistance) and the adequacy of oxygenation (arterial oxygen tension and arterial oxygen saturation). However, none of these variables describe the ultimate purpose of the cardiopulmonary system—to deliver sufficient amounts of oxygen to satisfy tissue demands.

This summary reviews how oxygen supply is threatened and how it can be assessed in individual patients. The determinants of oxygen delivery are discussed; the conditions that affect oxygen demand and how decreases in mixed venous oxygen saturation (SvO₂) can reflect the supply/demand imbalance. Decreases in SvO₂ can serve as an early warning of cardiopulmonary inadequacy, often long before hemodynamic instability occurs. Activities and conditions that increase tissue demand for oxygen help clinicians identify those patients whose oxygen demands should be controlled. Additionally, conditions that prevent tissue extraction of sufficient amounts of oxygen and increase SvO₂ are explained.

OXYGEN DELIVERY, DEMAND, AND SvO₂

Many critical care patients are unable to increase oxygen supply to match increased demand caused by events such as shivering, fever, physical agitation, or seizures. The most vulnerable patients are those whose supply system is incapable of meeting oxygen demands even in the resting state. When delivery is insufficient, the tissues “extract” more oxygen, resulting in slowed movement of oxygen into the cells.¹ Cell consumption of oxygen cannot meet cell demand, and oxygen debt, anaerobic metabolism, and lactic acidosis result, causing death if untreated or prolonged.^{2,3}

CONTINUOUS SvO₂ MONITORING TECHNOLOGY

The monitoring of SvO₂ can be used to track threats to oxygen supply/demand balance and to guide treatment that supports sufficient oxygenation of tissue. Introduced in 1981, the Opticath (now sold and marketed as TriOx from ICU Medical, Inc.) pulmonary artery (PA) catheter with fiber optics enables continuous monitoring of oxygen saturation of mixed venous blood.

CLINICAL APPLICATIONS: SvO₂ AS A REFLECTION OF DECREASED DELIVERY

SvO₂ monitoring is used in critically ill patients with respiratory failure to track:

- › SaO₂ and the adequacy of other delivery factors, such as CO and Hemoglobin (Hgb)
- › Extent to which oxygen consumption has been increased by work of breathing, fever, agitation, and other factors known to increase demands
- › Oxygen supply/demand status prior to and after suctioning⁴
- › Ventilator weaning, as a decrease in SvO₂ implies a deterioration in SaO₂/PaO₂ or an increase in work of breathing⁵
- › Assessment of ventilation after a position change, chest tube insertion, thoracentesis, or any change in ventilator settings or oxygen administration

Another clinical application is with the patient with decreased Hgb, as this threatens the delivery of oxygen to tissue.^{6,7} Decreased SvO₂ was found to be a more reliable indicator of occult bleeding than was change in heart rate, pulse pressure, central venous pressure, or pulmonary capillary wedge pressure.

Probably the most serious threat to oxygen supply in critical illness is any condition that decreases CO.⁸ In patients with cardiac compromise, monitoring for any decrease in SvO₂ can help determine the severity of the oxygen supply/demand balance and to guide the effectiveness of therapy designed to increase CO.

SVO₂ AS A REFLECTION OF INCREASED OXYGEN DEMANDS

An oxygen supply that may be adequate at rest will not be adequate if the need for oxygen is increased, which may occur during routine nursing care activities such as turning, bathing, or linen changes. SvO₂ monitoring can help pace nursing care according to the tolerance of the patient.

CONDITIONS THAT INCREASE SVO₂

Increased SvO₂ is associated with several dysfunctions in oxygen transport such as the presence of intracardiac shunts. Some cardiologists use continuous SvO₂ monitoring to reduce venous blood gas sampling time and costs. Also, cyanide toxicity inhibits oxygen processing by the mitochondria, which results in an increased SvO₂.

A major cause of abnormal transport and cellular use of oxygen is the septic syndrome, in which reduced oxygen consumption by active organs can result from maldistributions in blood flow.⁹ Some studies have shown that increased SvO₂ and decreased VO₂ are early indicators of the onset of the septic syndrome.^{10,11,12}

SUMMARY

Assessment of hemodynamic and pulmonary function using PA catheters and arterial blood gas analysis has become standard in the care of the critically ill. However, the data provided focus on the status of the supply of oxygen, but not on how well the supply is meeting the demand of the tissues. Continuous SvO₂ monitoring provides ongoing assessment of the oxygen supply/demand imbalance and may be used to initiate efforts to improve supply or control demand to reverse any imbalances that threaten the stability of the patient. To ensure that tissues are well-oxygenated, oxygen supply and demand are new targets of therapy for the critically ill patient.

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