VALUE OF SvO₂ IN SEPSIS

Thierry Boulain
Jean-Louis Teboul

Mixed venous oxygen saturation (SvO₂) has been known for a long time to be a meaningful physiological parameter that would reflect the global balance between arterial oxygen delivery (DO₂) and oxygen consumption (VO₂) provided that arterial blood oxygen saturation (SaO₂) is well-maintained. Shock states are characterized by imbalance between oxygen supply to the tissues and tissue oxygen demand. Because monitoring of SvO₂ is now easy to perform with fiberoptic pulmonary artery catheters (PACs), it is often used to assess global oxygen balance in shock states, in particular in septic shock. In this chapter, we will see that the interpretation of SvO₂ and its changes must be particularly careful in this setting for at least two major reasons: first, in shock states, by definition, oxygen demand exceeds VO₂ and second, the capacity of the tissues to utilize oxygen is often impaired in sepsis so that VO₂ may decrease relatively to oxygen demand, even if DO₂ is normal or high. Thus, although SvO₂ monitoring has been shown to be useful in the care of cardiac patients for instance [1], its value in sepsis and septic shock may be questioned [2,3].

DETERMINANTS OF SvO₂

The blood flowing through the pulmonary artery comes from the superior and inferior vena cavae, and from the coronary sinus and is thus the mixture of all the venous returns of the body. The amount of oxygen present in mixed venous blood (the mixed venous oxygen content: CvO₂) depends upon the amount of oxygen carried from the lungs toward the peripheral tissues by the cardiovascular system, and the whole-body VO₂. In the vast majority of clinical situations, CvO₂ is well and linearly correlated with SvO₂, which
represents the oxygen saturation (expressed in %) of hemoglobin contained by the red blood cells (RBC) of the mixed venous blood.

\( \text{CvO}_2 \) is the sum of oxygen bound to hemoglobin and of dissolved oxygen in the mixed venous blood:

\[
\text{CvO}_2 (\text{ml/100ml}) = (\text{SvO}_2 \times \text{Hb} \times 1.34) + (0.003 \times \text{PvO}_2) \quad (\text{Eqn 1})
\]

where Hb (g/dl) is the hemoglobin concentration, 1.34 is the oxygen combining capacity of hemoglobin, 0.003 is the oxygen dissolving coefficient in blood, and \( \text{PvO}_2 \) (mm Hg) is the partial pressure of oxygen in mixed venous blood. In most clinical cases, dissolved oxygen \((\text{PvO}_2 \times 0.003)\) does not contribute significantly to \( \text{CvO}_2 \). Thus:

\[
\text{CvO}_2 = (1.34 \times \text{Hb}) \times \text{SvO}_2 \quad (\text{Eqn 2})
\]

Similarly, the arterial oxygen content can be calculated as follows:

\[
\text{CaO}_2 = (1.34 \times \text{Hb}) \times \text{SaO}_2 \quad (\text{Eqn 3})
\]

where \( \text{SaO}_2 \) is the arterial blood oxygen saturation.

The Fick equation that states that:

\[
\text{VO}_{2} = \text{cardiac output} \times (\text{CaO}_2 - \text{CvO}_2) \quad (\text{Eqn 4})
\]

where \( \text{VO}_{2} \) is expressed in ml/min, and cardiac output expressed in dl/min, becomes:

\[
\text{VO}_{2} = \text{cardiac output} \times (\text{SaO}_2 - \text{SvO}_2) \times 1.34 \times \text{Hb} \quad (\text{Eqn 5})
\]

and \( \text{SvO}_2 \) can be expressed as:

\[
\text{SvO}_2 = \text{SaO}_2 - \left[ \text{VO}_{2} / (\text{cardiac output} \times \text{Hb} \times 1.34) \right] \quad (\text{Eqn 6})
\]

Thus, \( \text{SaO}_2 \), Hb, cardiac output, and \( \text{VO}_{2} \) are the four major physiological variables which determine the value of \( \text{SvO}_2 \).

In healthy subjects at rest with normal \( \text{SaO}_2 \) and Hb, the value of \( \text{SvO}_2 \) ranges from 70 to 75%. During exercise, oxygen demand is increased especially in skeletal muscles. As a consequence, \( \text{VO}_{2} \) will increase because of the increase in cardiac output and of the increase in oxygen extraction of the tissues that occurs especially in the skeletal muscles by redistribution of the intra-organ blood flow. For this reason, values as low as 45% for \( \text{SvO}_2 \) can be observed in healthy subjects during exercise [4]. However, when \( \text{SvO}_2 \)