Central venous oxygen saturation ($ScvO_2$) monitoring – temptations and pitfalls

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The oxygen saturation of the mixed venous blood (SvO_2), which can be sampled from the distal port of a pulmonary artery catheter (PAC), offers important hemodynamic information. According to the Fick principle, the content of the mixed venous blood correlates directly with the arterial oxygen content and with the cardiac output (CO), and inversely with the oxygen consumption. Since the SvO_2 is the major determinant of the mixed venous oxygen content, it can be quite reliably used in its place. Hence, a decrease in CO or in arterial oxygenation, or an increase in oxygen consumption, will decrease the SvO_2. Continuous monitoring of SvO_2 by special fiberoptic PAC has been introduced years ago and has been used mainly for the continuous assessment of CO. With the introduction of newer direct methods of continuous CO monitoring and the decreased use of PAC's in general, the continuous monitoring of SvO_2 has declined.

Renewed interest in the measurement of central venous oxygen saturation has developed following the landmark study of Rivers et al (*Early goal-directred therapy in the treatment of severe sepsis and septic shock. NEJM 2001; 345:1368-77*), in which early goal-directed therapy was shown to reduce mortality in septic patients. In this study, the saturation of central venous blood ($ScvO_2$), measured continuously by a specially designed fiberoptic central venous catheter, served as the major end-point of hemodynamic resuscitation, with 70% being the target SvO_2 value. Following this study, the Surviving Sepsis Campaign (SSC) has been launched and endorsed by many professional organizations, including the SCCM and the ESICM. According to the guidelines of the SSC (*Dellinger RP et al, Surviving Sepsis Campaign guidelines for management of severe sepsis and septic shock. Crit Care Med 2004; 32:858 –873*) the goals of the initial hemodynamic resuscitation of the septic patient should include a CVP of 8-12 mm Hg, mean arterial pressure $\geq$ 65 mm Hg, urine output $\geq$ 0.5 mL/kg/h and a $ScvO_2$ value of $\geq$ 70%.

There are various aspects of these guidelines which are beyond the scope of this discussion. However, the use of the $ScvO_2$ as a hemodynamic goal in septic patients presents a few potential problems. These include the following:

1) Central venous oxygen saturation is highly dependent on the site of measurement. Ideally, there must be complete mixing of blood from both the superior and inferior venae cavae, as is the case with the SvO_2. Since the $ScvO_2$ is measured in blood from the superior vena cava mainly, its value is usually about 5% higher

than that of the SvO_2. In addition, the depth of central venous catheter insertion, e.g., superior vena cava or right atrium, may affect the measurement as well.

2) The initial $ScvO_2$ values of the patients in the Rivers study were extremely low (about 50%) due most probably to low CO due to frank hypovolemia. However, sepsis is characterized by a decrease in tissue oxygen utilization and extraction due to maldistribution of blood flow within organs and perturbation of cellular metabolism despite adequate perfusion. The central venous oxygen saturation of septic shock patients is therefore mainly normal or even supra-normal since oxygen extraction is very close to (1- SvO_2). Obviously, in the presence of low oxygen extraction $ScvO_2$ is expected to be high even in the presence of inadequate perfusion. Thus when the $ScvO_2$ in the septic patient is normal or high, one cannot assume that all is well. A number of such examples will be presented during the lecture.

3) A low $ScvO_2$, like a low CO, tells us that something is wrong, but not what is wrong and what should be done about it (fluids? inotropes?).

In summary, the $ScvO_2$ may be used as a first-line monitoring method in patients who are at risk of developing hemodynamic instability. However, although short-term $ScvO_2$ changes in septic patients may be of diagnostic and prognostic significance, using this parameter in a goal-directed approach during sepsis should be done with caution and reservation.