A mysterious difference between central and mixed venous oxygen saturation after cardiac surgery

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Abstract

We report a case of unusual large differences between central venous oxygen saturations determined from different catheters in the central venous position in a patient after elective cardiac surgery. We discuss possible explanations and conclude that it may be worthwile to be more aggressive in obtaining real SvO2 data before reacting on ScvO2 levels in unclear haemodynamic situations.

Implications

Central venous oxygen saturation ($ScvO_2$) is increasingly used as a substitute for mixed venous oxygen saturation to monitor critically ill patients. Large differences of $ScvO_2$ determined from different catheters in the central venous position may render this technique more complicated as it seems at first glance.

Introduction

Central venous oxygen saturation ($ScvO_2$) is increasingly used as a substitute for mixed venous oxygen saturation (SvO_2) (1). Despite it is well known that the relation between $ScvO_2$ and SvO_2 may differ markedly in comparison between the awake state and general anesthesia, and that the difference between both parameters may spread during circulatory shock states, the determination of $ScvO_2$ has been suggested to be a clinically useful estimate of SvO_2 (2). Here we report a case of an unusual large difference between $ScvO_2$ and SvO_2 levels in a patient after elective cardiac surgery that led to possibly unnecessary therapeutic interventions.

Case report

A 46 year old male patient with grade IV aortic regurgitation, an aneurysma of the ascending aorta, and three-vessel coronary artery disease underwent elective aortocoronary bypass surgery (CABG), ascending aorta replacement, and aortic valve repair (Yacoub procedure). The left ventricular ejection fraction prior to surgery was 78%.

The patient was equipped with a left radial arterial line, a central venous catheter, and a 9F introducer via the right internal jugular vein. After induction with etomidate and sufentanil, the patient was ventilated with 60% oxygen in air; the respiratory rate was adjusted to achieve normocapnia. A central venous blood sample (ABL Radiometer, Copenhagen, Denmark) before sternotomy revealed a $ScvO_2$ of 67.4%.

Standard cardiopulmonary bypass (CPB) was performed. Cardiac arrest was achieved using antegrade blood cardioplegia as described by Buckberg. The replacement of the ascending aorta was performed in deep hypothermia (18°C nasopharyngeal temperature) with 19 minutes cardiocirculatory arrest. The cardiopulmonary bypass time was 200 minutes, aortic cross-clamp time was 167 minutes.

After uneventful weaning from CPB, the patient received four units of fresh frozen plasma and one unit of thrombocytes. No inotropes were used. The central venous saturation directly after CPB was 91.9%.

One hour after admission to the intensive care unit - still on mechanical ventilation and sedated with propofol - a further blood sample revealed a $ScvO_2$ of 53%. The patient received intravenous milrinone (0.24 $\mu g \cdot kg^{-1} \cdot min^{-1}$) with a loading dose of 50 $\mu g \cdot kg^{-1}$, but 20 minutes later $ScvO_2$ was 49 %. After infusion of two units of packed red blood cells, increasing the hemoglobin level from 7.7 g/dl^{-1} to 10.1 g/dl^{-1}, the $ScvO_2$ was 60% but fell again 30 minutes later to 39.8%. The patient's extremities were slightly cold, no shivering was detected. The haemodynamic profiles and arterial lactate levels are given in table 1. Sodium nitroprusside (0.5 $\mu g \cdot kg^{-1} \cdot min^{-1}$) was infused to maintain systolic arterial blood pressure below 130 mm Hg.

A pulmonary artery catheter (PAC) was introduced and, after reaching the central venous position as judged by the identical pressure curve with the central venous line, blood samples were drawn simultanously from the central venous and pulmonary artery catheter. Oxygen saturations were 54.8% and 91.9%, respectively. The PAC was further advanced into the pulmonary artery until a wedged-pressure curve was observed. A mixed-venous blood sample revealed a SvO_2 of 77%. The cardiac index was 2.6 $l \cdot min^{-1} \cdot m^{-2}$.

Anterior-posterior chest X-ray revealed the correct positioning of the central venous and the pulmonary artery catheter (Figure 1).

The patient's further course was uneventful. Extubation was feasible 13 hours after admission to the intensive care unit. One week later the patient was discharged from the hospital.

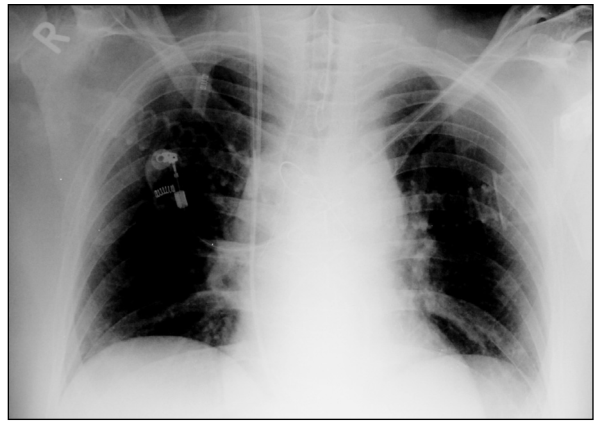

Figure 1. Anterior-posterior chest X-ray

Discussion

In healthy, awake individuals $ScvO_2$ is usually lower than SvO_2. This changes during anesthesia, head trauma, shock, severe heart failure, or sepsis (3). However, the mean difference between SvO_2 and $ScvO_2$ has been reported to be around 5 in stable critically ill patients (4), leading to the suggestion that $ScvO_2$ may be used instead of SvO_2 on many occasions.

We have no explanation for the discrepancies between the $ScvO_2$ levels determined from the central venous line, the $ScvO_2$ sampled from the PAC in the central venous position, and SvO_2. Dueck et al. observed an enormous variability between $ScvO_2$ and SvO_2 levels but also between SvO2 and the saturation in the right atrium (2). As the catheter was exactly positioned in the V. cava superior, well apart from the right atrium (Figure 1), mixing with desaturated blood from the coronary sinus is highly unlikely. A possible explanation may be that the central venous catheter was positioned near the mouth of the azygos vein. However, with a lack of echocardiographic data this remains purely speculative.

Table 1. Haemodynamic profile and arterial lactate

	ICU	1 h	2 h	3 h	4 h	5 h	6 h	7 h	8 h
MAP	83	85	83	85	91	83	80	74	60
HR	100	100	100	100	100	100	100	100	100
CI				2.6	2.6	2.7	2.7	2.8	2.8
SvO_2				77	73	69	66	66	72
Lactate	1.4	1.8	2.2	2.2	2.1		1.7		1.4

ICU: Admittance to the Intensive Care Unit; h: Hour; MAP: Mean arterial pressure (mm Hg); HR: Heart rate (beats per minute); CI: Cardiac index ($l \cdot min^{-1} \cdot m^{-2}$); SvO_2: Mixed venous oxygen saturation (%); Lactate: Arterial lactate (mmol / l^{-1}).

Other possible explanations for different venous oxygen saturations include congenital heart diseases with a left-right shunt, as atrial septum defect or partial anomalous pulmonary venous drainage. This is very unlikely because preoperative diagnostic, including computer tomography, angiography and echocardiography did not reveal such pathologies.

Nonetheless, facing such large differences between $ScvO_2$ levels determined from different catheters in the central venous position and between $ScvO_2$ and SvO_2 values, the question arises, if the uncertainties of $ScvO_2$ determination (awake or not awake; posture associated changes in catheter position) may render this technique more complicated as it seems at first glance. This assumption is supported by recent data from Sander and coworkers showing that a lack of agreement between $ScvO_2$ and SvO_2 in patients undergoing cardiac surgery if oxygen extraction is high and $ScvO_2$ concentrations are lower than 70% (5). With respect to the potential consequences (i.e. a transfusion in a young patient) we thus suggest that it may be worthwile to be more aggressive in obtaining real SvO_2 (and cardiac output) data before reacting on $ScvO_2$ levels in unclear hemodynamic situations.

References

1. Reinhart K, Bloos F. The value of venous oximetry. Curr Opin Crit Care 2005;11:259-63
2. Dueck MH, Klimek M, Appenrodt S et al. Trends but not individual values of central venous oxygen saturation agree with mixed venous oxygen saturation during varying hemodynamic conditions. Anesthesiology 2005;103:249-57
3. Reinhart K, Kuhn HJ, Hartog C, Bredle DL. Continuous central venous and pulmonary artery oxygen saturation monitoring in the critically ill. Intensive Care Med 2004;30:1572-8
4. Chawla LS, Zia H, Gutierrez G et al. Lack of equivalence between central and mixed venous oxygen saturation. Chest 2004;126:1891-6
5. Sander M, Spies CD, Foer A, Weymann L, Braun J, Volk T, Grubitzsch H, von Heymann C. Agreement of central venous saturation and mixed venous saturation in cardiac surgery patients. Intensive Care Med 2007; 33: 1719-25

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