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 worthwhile to be more aggressive in obtaining real SvO₂ data before reacting on ScvO₂ levels in unclear haemodynamic situations.

Implications

Central venous oxygen saturation (ScvO₂) is increasingly used as a substitute for mixed venous oxygen saturation to monitor critically ill patients. Large differences of ScvO₂ determined from different catheters in the central venous position may render this technique more complicated as it seems at first glance.

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 ScvO₂ 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 cardiopulmonary bypass time was 200 minutes, aortic cross-clamp time was 167 minutes.

Introduction

Central venous oxygen saturation (ScvO₂) is increasingly used as a substitute for mixed venous oxygen saturation (SvO₂) (1). Despite it is well known that the relation between ScvO₂ and SvO₂ 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 ScvO₂ has been suggested to be a clinically useful estimate of SvO₂ (2). Here we report a case of an unusual large difference between ScvO₂ and SvO₂ levels in a patient after elective cardiac surgery that led to possibly unnecessary therapeutic interventions.
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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 ScvO₂ of 53%. The patient received intravenous milrinone (0.24 µg·kg⁻¹·min⁻¹) with a loading dose of 50 µg·kg⁻¹, but 20 minutes later ScvO₂ 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 ScvO₂ 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 µg·kg⁻¹·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 simultaneously 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 SvO₂ of 77%. The cardiac index was 2.6 l·min⁻¹·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.

### Discussion

In healthy, awake individuals ScvO₂ is usually lower than SvO₂. This changes during anesthesia, head trauma, shock, severe heart failure, or sepsis (3). However, the mean difference between SvO₂ and ScvO₂ has been reported to be around 5 in stable critically ill patients (4), leading to the suggestion that ScvO₂ may be used instead of SvO₂ on many occasions.

We have no explanation for the discrepancies between the ScvO₂ levels determined from the central venous line, the ScvO₂ sampled from the PAC in the central venous position, and SvO₂. Dueck et al. observed an enormous variability between ScvO₂ and SvO₂ 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

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<td>69</td>
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<td>2.1</td>
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</table>

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·min⁻¹·m⁻²); SvO₂: 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 worthwhile to be more aggressive in obtaining real SvO\(_2\) (and cardiac output) data before reacting on ScvO\(_2\) levels in unclear hemodynamic situations.

References


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