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### Risk Analysis

- *** Very Highly Recommended
- ** Highly Recommended
- * Recommended

'This document is intended to provide information to an international audience outside of the USA'
1. **REVIEWS**

   Tanczos K & Molnar Z
   **The oxygen supply-demand balance: A monitoring challenge**
   Best Pract Res Clin Anaesthesiol 2013; 27(2): 201-7
   
   Ducrocq N, Kimmoun A, Levy B
   **LACTATE or ScvO2 as an endpoint in resuscitation of shock states?**
   Minerva Anestesiol 2013; 79(9): 1049-58
   
   Reid M
   **Central venous oxygen saturation: analysis, clinical use and effects on mortality**
   
   Walley KR.
   **Use of Central Venous Oxygen Saturation to Guide Therapy**
   Am J Respir Crit Care Med 2011;184:514-20
   
   Bauer P, Reinhart K, Bauer M.
   **Early goal directed therapy and outcome in septic shock**
   Int J Intensive Care 2007; Autumn:19-24
   
   Marx G, Reinhart K.
   **Venous oximetry**
   Curr Opin Crit Care 2006; 12:263-8
   
   Goodrich C.
   **Continuous central venous oximetry monitoring**
   
2. **GUIDELINES AND STANDARD OPERATING PROCEDURES**

   Reinhart K, Brunkhorst FM et al.
   **[Prevention, diagnosis, treatment, and follow-up care of sepsis. First revision of the S2k Guidelines of the German Sepsis Society (DSG) and the German Interdisciplinary Association for Intensive and Emergency Care Medicine (DIVI)].**
   Ger Med Sci 2010; Doc 14
   
   **Surviving Sepsis Campaign: International guidelines for management of severe sepsis and septic shock: 2008**
   Intensive Care Med 2008; 34(1): 17-60
De Oliveira CF, de Oliveira DS, Gottschald AF, Moura JD, Costa GA, Ventura AC, Fernandes JC, Vaz FA, Carcillo JA, Rivers EP, Troster EJ.

**ACCM / PALS haemodynamic support guidelines for paediatric septic shock: an outcomes comparison with and without monitoring central venous oxygen saturation**

ICM 2008; 34 (6): 1065-75

- - -


**S3 Guidelines for Intensive Care in Cardiac Surgery Patients: Haemodynamic Monitoring and Circulatory system**

Ger Med Sci 2010; 8: Doc 12

- - -

Trzeciak S, Dellinger RP, Abate NL, Cowan RM, Stauss M, Kilgannon JH, Zanotti S, Parrillo JE.

**Translating research to clinical practice: a 1-year experience with implementing early goal-directed therapy for septic shock in the emergency department**

Chest 2006; 129:225-32

- - -

3. **OUTCOME PAPERS**

Smetkin AA, Kirov M, Kuzkov VV, Lenkin AI, Eremeev AV, Slastilin VY, Borodin VV, Bjertnaes LJ.

**Single transpulmonary thermodilution and continuous monitoring of central venous oxygen saturation during off-pump coronary surgery.**


- - -

Csontos C, Foldi V, Fischer T, Bogar L.

**Arterial thermodilution in burn patients suggests a more rapid fluid administration during early resuscitation.**


- - -

de Oliveira CF, de Oliveira DS, Gottschald AF, Moura JD, Costa GA, Ventura AC, Fernandes JC, Vaz FA, Carcillo JA, Rivers EP, Troster EJ.

**ACCM/PALS haemodynamic support guidelines for paediatric septic shock: an outcomes comparison with and without monitoring central venous oxygen saturation.**


- - -

Kortgen A, Niederprün P, Bauer M.

**Implementation of an evidence-based „standard operating procedure“ and outcome in septic shock**

Crit Care Med 2006; 34(4):943-9

- - -


**Early goal-directed therapy in the treatment of severe sepsis and septic shock**


- - -

4. **METHODOLOGY AND VALIDATION**

4.1 **ScvO₂ vs. SvO₂**

el-Masry A, Mukhtar MA, el-Sherbieny AM, Fathy M, el-Meteini M

**Comparison of central venous oxygen saturation and mixed venous oxygen saturation during liver transplantation**

Anaesthesia 2009; 64(4): 378-82

- - -
Kopterides P, Bonovas S, Mavrou I, Kostadima E, Zakynthinos E, Armaganidis AS.
Venous Oxygen Saturation and Lactate Gradient from Superior Vena Cava to Pulmonary Artery in Patients with Septic Shock
Shock 2009; 31(6): 561-7

Agreement of central venous saturation and mixed venous saturation in cardiac surgery patients

Reinhart K, Kuhn HJ, Hartog C, Bredle DL.
Continuous central venous and pulmonary artery oxygen saturation monitoring in the critically ill
Curr Opin Crit Care 2004; 30:1572-8

Central venous and mixed venous oxygen saturation in critically ill patients
Respiration 2001; 68:279-85

4.2 Continuous ScvO2
Continuous central venous oxygenation measurement by CeVOX in patients undergoing off-pump coronary bypass grafting
Crit Care 2006;P340

Rivers ER, Nguyen B, Havstad S, Ressler J, Muzzin A, Peterson E, Tomlanovich M.
Early goal-directed therapy in the treatment of severe sepsis and septic shock

Rady MY, Rivers EP, Martin GB, Smithline H, Appelton T, Nowak RM.
Continuous central venous oximetry and shock index in the emergency department: use in the evaluation of clinical shock

4.3 CeVOX Validation
Continuous monitoring of ScvO(2) by a new fibre-optic technology compared with blood gas oximetry in critically ill patients: a multicentre study
Intensive Care Med 2007; 33(10): 1767-70

Muller M, Lohr T, Scholz S, Thul J, Akinturk H, Hempelmann G.
Continuous SvO(2) measurement in infants undergoing congenital heart surgery - first clinical experiences with a new fiberoptic probe

Ducart A, Dejonckheere M, Koch M, Perrin L, Schmartz D.
Continuous central venous and pulmonary artery oxygen saturation monitoring in cardiac surgery after cardiopulmonary bypass
Eur J Anaesthesiol 2007; 4AP2-7
Huber D, Osthause W, Optenhöfel J, Breymann T, Marx G, Piepenbrock S, Sümpelmann R.
Continuous monitoring of central venous oxygen saturation in neonates and small infants: in vitro evaluation of two different oximetry catheters
Paediatr Anaesth 2006; 16(12):1257-61

Continuous central venous oxygenation measurement by CeVOX in patients undergoing off-pump coronary bypass grafting
Crit Care 2006:P340

4.4 ScvO2 and Blood Gas Analysis Cost Comparison
Bloos F, Rissner F, Specht M, Reinhart K, Marx G
Costs of intermittent measurement of central venous oxygen saturations by blood gas analysis
Intensive Care Med 2009; 35(7): 1316-7

5. Fields of Application

5.1 Septic Shock
Shin TG, Jo IJ, Hwang SY, Jeon K, Suh GY, Choe E, Lee YK, Lee TR, Cha WC, Sim MS
Comprehensive Interpretation of Central Venous Oxygen Saturation and Blood Lactate Levels During Resuscitation of Patients With Severe Sepsis and Septic Shock in the Emergency Department
Shock 2016; 45(1): 4-9

Park JH, Lee J, Park YS, Lee CH, Lee SM, Yim JJ, Kim YW, Han SK, Yoo CG
Prognostic Value of Central Venous Oxygen Saturation and Blood Lactate Levels Measured Simultaneously in the Same Patients with Severe Systemic Inflammatory Response Syndrome and Severe Sepsis
Lung 2014; 192(3): 435-40

Maddirala S and Khan A
Optimizing hemodynamic support in septic shock using central and mixed venous oxygen saturation
Crit Care Clin 2010; 26(2): 323-33

Pope JV, Jones AE, Gaieski DF, Arnold RC, Trzeciak S, Shapiro NI
Multicenter Study of Central Venous Oxygen Saturation (ScvO2) as a Predictor of Mortality in Patients With Sepsis

Implementation of a bundle of quality indicators for the early management of severe sepsis and septic shock is associated with decreased mortality
Crit Care Med 2007; 35 (4): 1105 - 12

Kortgen A, Niederprün P, Bauer M.
Implementation of an evidence-based „standard operating procedure“ and outcome in septic shock
Trzeciak S, Dellinger RP, Abate NL, Cowan RM, Stauss M, Kilgannon JH, Zanotti S, Parrillo JE.
Translating research to clinical practice: a 1-year experience with implementing early goal-directed therapy for septic shock in the emergency department
Chest 2006;129: 225-32

Early goal-directed therapy in the treatment of severe sepsis and septic shock
N Eng J Med 2001; 345:1368–77

5.2 Cardiogenic Shock and Cardiopulmonary Resuscitation
Chin K, Channick RN, Kim NH, Rubin LJ.
Central venous blood oxygen saturation monitoring in patients with chronic pulmonary arterial hypertension treated with continuous IV epoprostenol: correlation with measurements of hemodynamics and plasma brain natriuretic peptide levels.

Ander DS, Jaggi M, Rivers E, Rady MY, Levine TB, Levine AB, Masura J, Gryzbowski M.
Undetected cardiogenic shock in patients with congestive heart failure presenting to the emergency department
Am J Cardiol 1998; 82:888-91

Rivers EP, Martin GB, Smithline H, Rady MY, Schultz CH, Goetting MG, Appleton TJ, Nowak RM.
The clinical implications of continuous central venous oxygen saturation during human CPR

Rivers EP, Rady MY, Martin GB, Fenn NM, Smithline HA, Alexander ME, Nowak RM.
Venous hyperoxia after cardiac arrest. Characterization of a defect in systemic oxygen utilization
Chest. 1992; 102(6):1787-93

5.3 Emergency Medicine
Trzeciak S, Dellinger RP, Abate NL, Cowan RM, Stauss M, Kilgannon JH, Zanotti S, Parrillo JE.
Translating research to clinical practice: a 1-year experience with implementing early goal-directed therapy for septic shock in the emergency department
Chest 2006; 129:225-32

Early goal-directed therapy in the treatment of severe sepsis and septic shock
N Eng J Med 2001; 345:1368–77

Rady MY, Rivers EP, Nowak RM.
Resuscitation of the critically ill in the ED: responses of blood pressure, heart rate, shock index, central venous oxygen saturation, and lactate
5.4 Cardiac Surgery
High central venous saturation after cardiac surgery is associated with increased organ failure and long-term mortality: an observational cross-sectional study
Crit Care 2015; 19(1): 168

Gasparovic H, Gabelica R, Ostojic Z, Kopjar T, Petricevic M, Ivancan V, Biocina B
Diagnostic accuracy of central venous saturation in estimating mixed venous saturation is proportional to cardiac performance among cardiac surgical patients
J Crit Care 2014; 29(5): 828-34

Hu BY, Laine GA, Wang S, Solis RT
Combined central venous oxygen saturation and lactate as markers of occult hypoperfusion and outcome following cardiac surgery

Perz S, Uhlig T, Kohl M, Bredle DL, Reinhart K, Bauer M, Kortgen A.
Low and "supranormal" central venous oxygen saturation and markers of tissue hypoxia in cardiac surgery patients: a prospective observational study.
Intensive Care Med 2011; 1: 52-9

Nogueira PM, Mendonca-Filho MT, Campos LA, Gomes RV, Felipe AR, Fernandes MA, Villela-Nogueira CA, Rocco JR.
Central Venous Saturation: A Prognostic Tool in Cardiac Surgery Patients

Smetkin AA, Kirov M, Kuzkov VV, Lenkin AI, Eremeev AV, Stastilin VY, Borodin VV, Bjertnaes LJ.
Single transpulmonary thermodilution and continuous monitoring of central venous oxygen saturation during off-pump coronary surgery.

5.5 General Surgery
Continuous central venous oxygen saturation assisted intraoperative hemodynamic management during major abdominal surgery: a randomized, controlled trial
BMC Anesthesiol 2015; 15: 82

Continuous monitoring of central venous oxygen saturation predicts postoperative liver dysfunction after liver resection
Surgery 2013; 154(82): 351-62

Jakob S.
Multicentre study on peri-postoperative central venous oxygen saturation in high-risk surgical patients
Critical Care 2006; 10:R158

Pearse R, Dawson D, Fawcett J, Rhodes A, Grounds RM, Bennett ED.
Changes in central venous saturation after major surgery, and association with outcome
Crit Care 2005; 9:R694-9
5.6 Paediatrics (off label use)
de Oliveira CF, de Oliveira DS, Gottschald AF, Moura JD, Costa GA, Ventura AC, Fernandes JC, Vaz FA, Carcillo JA, Rivers EP, Troster EJ.

ACCM/PALS haemodynamic support guidelines for paediatric septic shock: an outcomes comparison with and without monitoring central venous oxygen saturation.

Seear MD, ScarfeJC, LeblancJG.

Predicting major adverse events after cardiac surgery in children

Muller M, Lohr T, Scholz S, Thul J, Akinturk H, Hempelmann G.

Continuous SvO(2) measurement in infants undergoing congenital heart surgery - first clinical experiences with a new fiberoptic probe


Correlation of oxygen delivery with central venous oxygen saturation, mean arterial pressure and heart rate in piglets
Paediatr Anaesth. 2006; 16(9):944-7.

Huber D, Osthaus W, Optenhöfel J, Breymann T, Marx G, Piepenbrock S, Sümpelmann R.

Continuous monitoring of central venous oxygen saturation in neonates and small infants: in vitro evaluation of two different oximetry catheters
Paediatr Anesth. 2006; 16(12):1257-61

5.7 ScvO2 As Indicator For Blood Transfusion
Krantz T, Warberg J, Secher NH.

Venous oxygen saturation during normovolaemic haemodilution in the pig

Schou H, Perez de Sa V, Larsson A.

Central and mixed venous blood oxygen correlate well during acute normovolemic hemodilution in anesthetized pigs

5.8 Burns
Csontos C, Foldi V, Fischer T, Bogar L.

Arterial thermodilution in burn patients suggests a more rapid fluid administration during early resuscitation.

5.9 Medical

ScvO2 As a Marker to Define Fluid Responsiveness
J Trauma 2011;70(4): 802-7
Jansen TC, van Bommel J, Schoonderbeek J, Sleeswijk Visser SJ, van der Klooster JM, Lima AP, Willemsen SP, Bakker J
Early Lactate-Guided Therapy in ICU Patients: A Multicenter, Open-Label, Randomized, Controlled Trial.
Am J Respir Crit Care Med 2010; 182: 752-61

6. RISK ANALYSIS OF CENTRAL VENOUS CATHETERISATION

Gowardman JR, Robertson IK, Parkes S, Rickard CM
Influence of insertion site on central venous catheter colonization and bloodstream infection rates.

Crowley AL, Peterson GE, Benjamin DK Jr, Rimmer SH, Todd C, Cabell CH, Reller LB, Ryan T, Corey GR, Fowler VG Jr.
Venous thrombosis in patients with short- and long-term central venous catheter-associated Staphylococcus aureus bacteremia
Crit Care Med 2008; 36(2): 385-90

Koh DB, Gowardman JR, Rickard CM, Robertson IK, Brown A.
Prospective study of peripheral arterial catheter infection and comparison with concurrently sited central venous catheters
Crit Care Med 2008 36(2): 397-402

Schummer W, Schummer C, Rose N, Niesen WD, Sakka SG.
Mechanical complications and malpositions of central venous cannulations by experienced operators: A prospective study of 1794 catheterizations in critically ill patients

Eisen LA, Narasimhan M, Berger JS, Mayo PH, Rosen MJ, Schneider RF.
Mechanical complications of central venous catheters
J Int Care Med 2006; 21 (1): 40-6

Traore O, Liotier J, Souweine B.
Prospective study of arterial and central venous catheter colonization and of arterial- and central venous catheter-related bacteremia in intensive care units

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