Clinical Evidence

PiCCO Technology

This document is intended to provide information to an international audience outside of the US.

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Contents

Review articles & Guidlines

The PiCCO Technology provides a dynamic, minimally invasive measurement of cardiac output and its determinants (preload, afterload, contractility) as well as the quantification of pulmonary edema for a targeted treatment. It is a clinically proven tool for hemodynamic assessment and management in a broad range of critically ill patients. With its unique combination of intermittent transpulmonary thermodilution and continuous pulse contour analysis, the PiCCO Technology provides a complete picture of the hemodynamic situation. The basic principle of PiCCO has been explained in several review articles:

Review articles

- Tagami T, Eng Hock Ong M.

  Extravascular lung water measurements in acute respiratory distress syndrome: why, how, and when?

  Curr Opin Crit Care 2018;24(3):209-215
  DOI: 10.1097/MCC.0000000000000503

- Monnet X, Teboul JL.

  Transpulmonary thermodilution: advantages and limits.

  Critical Care. 2017;21:147

- Litton E, Morgan M.

  The PiCCO monitor: a review.

  Anaesth Intensive Care. 2012;40:393-409

- Sakka SG, Reuter DA, Perel A.

  The transpulmonary thermodilution technique.

  J Clin Monit Comput. 2012;26:347-53

- Oren-Grinberg A.

  The PiCCO Monitor.

  Int Anesthesiol Clin. 2010;48(1):57-85

Guidlines

- Kirov M, Kuzkov V, Bjertnaes L.

  Extravascular lung water as a target for intensive care.

  ICU Management & Practice 2019;19(1):46-50

- Teboul JL, Saugel B, Cecconi M, et al.

  Less invasive hemodynamic monitoring in critically ill patients.

  Intensive Care Med 2016;42:1350–1359

Cost effectiveness

Several publications have reported an improved patient outcome when advanced hemodynamic variables are used to set up a goal directed treatment algorithm. In these studies, a reduction in complication rates has been reported and the subsequent treatment costs were reduced. While the incorporation of advanced hemodynamic monitoring is associated with an (initial) investment, the cost-reduction due to the decrease in complications is always higher than the investment.

- Sadique Z, Harrison DA, Grieve R, Rowan KM, Pearse RM.
  Cost-effectiveness of a cardiac output-guided haemodynamic therapy algorithm in high-risk patients undergoing major gastrointestinal surgery.
  Perioper Med. 2015;4:13
- Michard F, Mountford WK, Krukas MR, Ernst FR, Fogel SL.
  Potential return on investment for implementation of perioperative goal-directed fluid therapy in major surgery: a nationwide database study.
  Perioper Med. 2015;4:11
- Manecke GR, Asemota A, Michard F.
  Tackling the economic burden of postsurgical complications: would perioperative goal-directed fluid therapy help.
  Crit Care. 2014;18(5):566
- Ebm CC, Sutton L, Rhodes A, Cecconi M.
  Cost-Effectiveness in goal-directed therapy: are the dollars spent worth the value.
  J Cardiothorac Vasc Anesth. 2014;28(6):1660-1666

Validation of PiCCO parameters

Accuracy of PiCCO thermodilution cardiac output compared to the pulmonary artery catheter

The two methods have comparable accuracy, however the PiCCO thermodilution method is less user-dependent and gives more stable measurements.

- Reuter D, Huang C, Edrich T, Shernan SK, Eltzschig HK.
  Cardiac output monitoring using indicator-dilution techniques: basics, limits, and perspectives.
  Anesth Analg. 2010;110(3):799-811
- Friesecke S, Heinrich A, Abel P, Felix SB.
  Comparison of pulmonary artery and aortic transpulmonary thermodilution for monitoring of cardiac output in patients with severe heart failure: validation of a novel method.
  Crit Care Med. 2009;37(1):119-123
- Felbinger TW, Reuter DA, Eltzschig HK, Bayerlein J, Goetz AE.
  Cardiac index measurements during rapid preload changes: a comparison of pulmonary artery thermodilution with arterial pulse contour analysis.
  J Clin Anesth. 2005;17(4):241-248
- Marx G, Schuerholz T, Sumpelmann R, Simon T, Leuwer M.
  Comparison of cardiac output measurements by arterial trans-cardiopulmonary and pulmonary arterial thermodilution with direct Fick in septic shock.
  Eur J Anaesthesiol. 2005;22(2):129-134
- Bein B, Worthmann F, Tonner PH, et al.
  Comparison of esophageal Doppler, pulse contour analysis, and real-time pulmonary artery thermodilution for the continuous measurement of cardiac output.
  J Cardiothorac Vasc Anesth. 2004;18(2):185-189
- Della Rocca G, Costa MG, Coccia C, Pompei L, Pietropaoli P.
  Preload and haemodynamic assessment during liver transplantation: a comparison between the pulmonary artery catheter and transpulmonary indicator dilution techniques.
  Eur J Anaesthesiol. 2002;19(12):868-875

Accuracy of PiCCO pulse contour cardiac output compared to the pulmonary artery catheter

Several validation studies of the PiCCO pulse contour cardiac output versus pulmonary artery thermodilution have been published, within the early days of introduction of PiCCO in the market.

- Felbinger TW, Reuter DA, Eltzschig HK, Bayerlein J, Goetz AE.

  Cardiac index measurements during rapid preload changes: a comparison of pulmonary artery thermodilution with arterial pulse contour analysis.

  J Clin Anesth. 2005;17(4):241-248

- Della Rocca G, Costa, MG Coccia C, Pompei L, Di Marco P.

  Cardiac output monitoring: aortic transpulmonary thermodilution and pulse contour analysis agree with standard thermodilution methods in patients undergoing lung transplantation.

  Can J Anaesth. 2003;50(7):707-711

- Mielck F, Buhre W, Hanekop G, Tirilomis T, Hilgers R, Sonntag H.

  Comparison of continuous cardiac output measurements in patients after cardiac surgery.

  J Cardiothorac Vasc Anesth. 2003;17(2):211-216

- Felbinger TW, Reuter DA, Eltzschig HK, Moerstedt K, Goedje O, Goetz AE.

  Comparison of pulmonary arterial thermodilution and arterial pulse contour analysis: Evaluation of a new algorithm.

  J Clin Anesth. 2002;14:296-301

- Zollner C, Haller M, Weiss M, et al.

  Beat-to-beat measurement of cardiac output by intravascular pulse contour analysis: a prospective criterion standard study in patients after cardiac surgery.

  J Cardiothorac Vasc Anesth. 2000;14(2):125-129

Accuracy of the lung water measurement (EVLW/ELWI) by PiCCO

Evidence shows that measurement of lung water with PiCCO for quantification of pulmonary edema is accurate and correlates strongly with the 'gold standard' gravimetric method.

- Venkateswaran RV, Dronavalli V, Patchell V, et al.

  Measurement of extravascular lung water following human brain death: implications for lung donor assessment and transplantation.

  Eur J Cardiothorac Surg. 2013;43(6):1227-1232

- Tagami T, Kushimoto S, Yamamoto Y, et al.

  Validation of extravascular lung water measurement by single transpulmonary thermodilution: human autopsy study.

  Crit Care. 2010;14(5):R162

- Kuzkov VV, Suborov EV, Kirov MY, et al.

  Extravascular lung water after pneumonectomy and one-lung ventilation in sheep.

  Crit Care Med. 2007;35(6):1550-1559

- Kirov MY, Kuzkov VV, Kuklin VN, Waerhaug K, Bjertnaes LJ.

  Extravascular lung water assessed by transpulmonary single thermodilution and postmortem gravimetry in sheep.

  Crit Care. 2004;8(6):R451

- Katzenelson R, Perel A, Berkenstadt H, Preisman S, Kogan S, Sternik L.

  Accuracy of transpulmonary thermodilution versus gravimetric measurement of extravascular lung water.

  Crit Care Med. 2004;32(7):1550-1554

Recommended clinical application areas

Critically ill patients

Septic shock

- Wang H, Cui N, Su L, et al.

  Prognostic value of extravascular lung water and its potential role in guiding fluid therapy in septic shock after initial resuscitation.

  J Crit Care 2016; 33:106-113

- Lu NF, Zheng RQ, Lin H, Shao J, Yu JQ, Yang G.

  Improved sepsis bundles in the treatment of septic shock: a prospective clinical study.

  Am J Emerg Med. 2015;33(8):1045-1049

- Chung FT, Lin HC, Kuo CH, et al.

  Extravascular lung water correlates multiorgan dysfunction syndrome and mortality in sepsis.

  PLoS One. 2010;5(12):e15265

- Ritter S, Rudiger A, Maggiorini M.

  Transpulmonary thermodilution-derived cardiac function index identifies cardiac dysfunction in acute heart failure and septic patients: an observational study.

  Crit Care. 2009;13(4):R133

- Wang H, Cui N, Su L, et al.

  Prognostic value of extravascular lung water and its potential role in guiding fluid therapy in septic shock after initial resuscitation.

  J Crit Care 2016; 33:106-113

Acute Respiratory Distress Syndrome (ARDS)

- Kor DJ, Warner D, Carter R, et al.

  Extravascular lung water and pulmonary vascular permeability index as markers predictive of postoperative acute respiratory distress syndrome: a prospective cohort investigation.

  Crit Care Med. 2014;43(3):665-673

- Tagami T, Nakamura T, Kushimoto S, et al.

  Early-phase changes of extravascular lung water index as a prognostic indicator in acute respiratory distress syndrome patients.

  Annals of Intensive Care. 2014;4:27

- Hu W, Lin CW, Liu BW, Hu WH, Zhu Y.

  Extravascular lung water and pulmonary arterial wedge pressure for fluid management in patients with acute respiratory distress syndrome.

  Multidiscip Respir Med. 2014;9(1):3

- Chew MS, Ihrman L, During J, et al.

  Extravascular lung water index improves the diagnostic accuracy of lung injury in patients with shock.

  Crit Care. 2012;16(1):R1

Cardiogenic shock

- Zhang YB, Zhang ZZ, Li JX, et al.

  Application of pulse index continuous cardiac output system in elderly patients with acute myocardial infarction complicated by cardiogenic shock: A prospective randomized study.

  World J Clin Cases 2019;7(11):1291-1301

- Schmid B, Fink K, Olschewski M, et al.

  Accuracy and precision of transcardiopulmonary thermodilution in patients with cardiogenic shock.

  J Clin Monit Comput. 2016 Dec;30(6):849-856. Epub 2015 Oct 1.

- Perny J, Kimmoun A, Perez P, Levy B.

  Evaluation of cardiac function index as measured by transpulmonary thermodilution as an indicator of left ventricular ejection fraction in cardiogenic shock.

  Biomed Res Int. 2014; Article ID 598029, **http://dx.doi.org/10.1155/2014/598029**

Severe burn injury

- Sanchez-Sanchez M, Garcia-de-Lorenzo A, Herrero E, et al.

  A protocol for resuscitation of severe burn patients guided by transpulmonary thermodilution and lactate levels: a 3-year prospective cohort study.

  Crit Care. 2013;17(4):R176

- Bognar Z, Foldi V, Rezman B, Bogar L, Csontos C.

  Extravascular lung water index as a sign of developing sepsis in burns.

  Burns. 2010;8:1263-1270

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

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

  Acta Anaesthesiol Scand. 2008;52(6):742-749

Neuro surgery (SAH)

- Obata Y, Takeda J, Sato Y, Ishikura H, Matsui T, Isotani E.

  A multicenter prospective cohort study of volume management after subarachnoid hemorrhage: circulatory characteristics of pulmonary edema after subarachnoid haemorrhage.

  J Neurosurg. 2015;1-10

- Mutoh T, Kazumata K, Terasaka S, Taki Y, Suzuki A, Ishikawa T.

  Impact of transpulmonary thermodilution-based cardiac contractility and extravascular lung water measurements on clinical outcome of patients with Takotsubo cardiomyopathy after subarachnoid hemorrhage: a retrospective observational study.

  Crit Care. 2014;18(4):482

- Mutoh T, Kazumata K, Terasaka S, Taki Y, Suzuki A, Ishikawa T.

  Early intensive versus minimally invasive approach to postoperative hemodynamic management after subarachnoid hemorrhage.

  Stroke. 2014;45(5):1280-1284

- Mutoh T, Kazumata K, Ishikawa T, Terasaka S.

  Performance of bedside transpulmonary thermodilution monitoring for goal-directed hemodynamic management after subarachnoid hemorrhage.

  Stroke. 2009;40(7):2368-74

Pancreatitis

- Sun Y, Lu ZH, Zhang XS, Geng XP, Cao LJ, Yin L.

  The effects of fluid resuscitation according to PiCCO on the early stage of severe acute pancreatitis.

  Pancreatology. 2015;15(5):497-502

- Trepte C, Bachmann K, Stork JH, et al.

  The impact of early goal-directed fluid management on survival in an experimental model of severe acute pancreatitis.

  Intensive Care Med. 2013;39(4):717-726

- Huber W, Umgelter A, Reindl W, et al.

  Volume assessment in patients with necrotizing pancreatitis: a comparison of intrathoracic blood volume index, central venous pressure, and hematocrit, and their correlation to cardiac index and extravascular lung water index.

  Crit Care Med. 2008;36(8):2348-2354

Cardiac surgery

- Goepfert M, Richter HP, Eulenburg CZ, et al.

  Individually optimized hemodynamic therapy reduces complications and length of stay in the intensive care unit: A prospective, randomized controlled trial.

  Anesthesiology. 2013;119(4):824-836

- Smetkin AA, Kirov M, Kuzkov VV, et al.

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

  Acta Anaesthesiol Scand. 2009;53:505-514

- Goepfert M, Reuter D, Akyol D, Lamm P, Kilger E, Goetz A.

  Goal-directed fluid management reduces vasopressor and catecholamine use in cardiac surgery patients.

  Intensive Care Medicine. 2007;33:96-103

High risk surgical procedures

- Oshima K, Kunimoto F, Hinohara H, et al.

  Evaluation of respiratory status in patients after thoracic esophagectomy using PiCCO system.

  Ann Thorac Cardiovasc Surg. 2008;14(5):283-288

- Sato Y, Motoyama S, Maruyama M, et al.

  Extravascular lung water measured using single transpulmon ary thermodilution reflects perioperative pulmonary edema induced by esophagectomy.

  Eur Surg Res. 2006;39(1):7-13

Transplantation

- Garutti I, Sanz J, Olmedilla L, et al.

  Extravascular lung water and pulmonary vascular permeability index measured at the end of surgery are independent predictors of prolonged mechanical ventilation in patients undergoing liver transplantation.

  Anesth Analg. 2015;121(3):736-745

- Minambres E, Coll E, Duerto J, et al.

  Effect of an intensive lung donor-management protocol on lung transplantation outcomes.

  J Heart Lung Transplant. 2014;33(2):178-184

- Venkateswaran RV, Dronavalli V, Patchell V, et al.

  Measurement of extravascular lung water following human brain death: implications for lung donor assessment and transplantation.

  Eur J Cardiothorac Surg. 2013;43(6):1227-1232

- Venkateswaran R, Patchell V, Wilson I, et al.

  Early donor management increases the retrieval rate of lungs for transplantation.

  Ann Thorac Surg. 2008;85:278-286

Liver Cirrhosis

- Wu CY, Cheng YJ, Liu YJ, et al.

  Predicting stroke volume and arterial pressure fluid responsiveness in liver cirrhosis patients using dynamic preload variables: A prospective study of diagnostic accuracy.

  Eur J Anaesthesiol 2016;33:645–652
  DOI: 10.1097/EJA.0000000000000479

Recommended clinical application areas
Pediatrics

General intensive care

Two femoral PiCCO catheters can be used in pediatrics (PV2013L07, 3F, 7cm and PV2014L08, 4F, 8cm). The decision about which kind of patient (age, weight) these catheters are used for, should be made by the treating physician. Recommendations on the body weight can be derived from publications e.g. Cecchetti et al. (Min Anest 2013), used a 3F catheter in a patient with body weight less than 10kg and 4F catheters in pediatric patients with at least 10kg body weight. In other publications, (e.g. Lemson et al., Crital Care 2010; Szekely et al., Ped Card 2010; Gil Anton et al., An Ped 2009; Egan et al, Intensive Care Med 2005; Cecchetti et al., Min Anest 2003) the youngest patients were aged 2 months with a body weight of 3 kg. A review on PiCCO in pediatrics was published by Proulx et al (Pediatr Crit Care Med 2011).

- Proulx F, Lemson J, Choker G, Tibby SM.
  Hemodynamic monitoring by transpulmonary thermodilution and pulse contour analysis in critically ill children.
  Pediatr Crit Care Med 2011;12(4):1-8
- Lemson J, van Die LE, Hemelaar AEA, van der Hoeven JG.
  Extravascular lung water index measurement in critically ill children does not correlate with a chest x-ray score of pulmonary edema.
  Crital Care 2010;14:R105
- Cecchetti C, Lubrano R, Cristaldi S, et al.
  Relationship between global end-diastolic volume and cardiac output in critically ill infants and children.
  Crit Care Med 2008; 36(3):928-932.
- Cecchetti C, Stoppa F, Vanacore N, et al.
  Monitoring of intrathoracic volemia and cardiac output in critically ill children.
  Minerva Anestesiol 2003;69:907-918

Normal ranges in pediatric patients

The normal ranges in pediatric patients are slightly different to those of adult patients. It has been shown that, the younger the patient and the lower their weight, the lower the GEDI and higher the ELWI.

- Nusmeier A, Cecchetti C, Blohm M, Lehman R, van der Hoeven J, Lemson J.
  Near-normal values of extravascular lung water in children.
  Pediatr Crit Care Med. 2015;16(2):e28-33
- Lemson J, Merkus P, van der Hoeven JG.
  Extravascular lung water index and global end-diastolic volume index should be corrected in children.
  J Crit Care. 2011;26(4):432.e7-12

Acute respiratory failure

- Lubrano R, Cecchetti C, Tomasello C, et al.

  Prognostic value of extravascular lung water index in critically ill children with acute respiratory failure.

  Intensive Care Med. 2011;37(1):124-131

Severe burn injury

- Kraft R, Herndon DN, Branski LK, Finnerty CC, Leonard KR, Jeschke MG.

  Optimized fluid management improves outcomes of pediatric burn patients.

  J Surg Res. 2013;181(1):121-128

- Branski LK, Herndon DN, Byrd JF, et al.

  Transpulmonary thermodilution for hemodynamic measurements in severely burned children.

  Crit Care. 2011;15(2):R118

Head trauma

- Cecchetti C, Elli M, Stoppa F, et al.

  Neurogenic pulmonary edema and variations of emodynamic volumetric parameters, in children following head trauma.

  Minerva Anestesiol. 2013;70(10):1140-1146

Transplantation

- Voet M, Nusmeier A, Lerou J, Luijten J, Cornelissen M, Lemson J.

  Cardiac output guided hemodynamic therapy for adult living donor kidney transplantation in children under 20 kg: A pilot study.

  Pediatric Anesthesia 2019;29:950–958

- Torgay A, Pirat A, Akpek E, Zeyneloglu P, Arslan G, Haberal M.

  Pulse contour cardiac output system use in pediatric orthotopic liver transplantation: preliminary report of nine patients.

  Transplant Proc. 2005;37(7):3168-3170

Cardiac surgery

- Gil-Anton J, Lopez-Bayon J, Lopez-Fernandez Y, Morteruel E, Perez-Estevez E, Lopez-Herce J.

  Cardiac index monitoring by femoral arterial thermodilution after cardiac surgery in children.

  J Crit Care. 2014;29(6):1132.e1-1132.e4

- Keller G, Desebbe O, Henaine R, Lehot JJ.

  Transpulmonary thermodilution in a pediatric patient with an intracardiac left-to-right shunt.

  J Clin Monit Comput. 2011;25(2):105-108

- Szekely A, Breuer T, Sapi E, et al.

  Transpulmonary thermodilution in neonates undergoing arterial switch surgery.

  Pediatr Cardiol. 2011;32(2):125-130

- Fakler U, Pauli Ch, Balling G, et al.

  Cardiac index monitoring by pulse contour analysis and thermodilution after pediatric cardiac surgery.

  J Thorac Cardiovasc Surg. 2007;133(1):224-228

- Cherqaoui I, Raux O, Dehour L, Rochette A, Dadure C, Capdevila X.

  Transpulmonary thermodilution hemodynamic monitoring for pheochromocytoma surgery in a child with complex congenital heart disease.

  Paediatr Anaesth. 2006;16(12):1277-1280

- Egan J, Festa M, Cole A, Nunn GR, Gillis J, Winlaw DS.

  Clinical assessment of cardiac performance in infants and children following cardiac surgery.

  Intensive Care Med. 2005;31(4):568-573

- Mahajan A, Shabanie A, Turner J, Sopher MJ, Marijic J.

  Pulse contour analysis for cardiac output monitoring in cardiac surgery for congenital heart disease.

  Anesth Analg. 2003;97(5):1283-1288

Clinical & medical questions

Influence on PiCCO measurements in special clinical situations and therapies

Clinical situations

Aortic aneurysm

In patients with a known aortic aneurysm, if a femoral arterial catheter is used, the GEDI will be overestimated due to the volume of the aneurysm itself. In these cases, a brachial or axillary PiCCO catheter is recommended.

- Antonini M, Meloncelli S, Dantimi C, Tosti S, Ciotti L, Gasparetto A.

  [The PiCCO system with brachial-axillary artery access in hemodynamic monitoring during surgery of abdominal aortic aneurysm].

  Minerva Anestesiol. 2001;67(6):447-456. 320-324

Valvulopathies, cardiac valve insufficiencies

Valve insufficiency, especially aortic valve insufficiency, may cause regurgitation of the thermodilution injectate and prolong the transit time of the indicator; or interfere with the thermodilution curve. However, when a sufficient thermodilution curve is detected, the calculation of the cardiac output is considered correct. In mitral valve insufficiency, the accuracy of the PiCCO cardiac output measurement has been confirmed.

- Staier K, Wilhelm M, Wiesenack C, Thoma M, Keyl C.

  Pulmonary artery vs. transpulmonary thermodilution for the assessment of cardiac output in mitral regurgitation: a prospective method comparison study.

  Eur J Anaesthesiol. 2012;29(9):431-437

Aortic stenosis

In aortic stenosis, arterial thermodilution accurately reflects cardiac output. The arterial pressure curve may have reduced systolic and elevated diastolic pressures. However, the area under the arterial curve still reflects stroke volume. In severe aortic stenosis, recalibration of the pulse contour (with thermodilution) substantially improves reliability.

- Petzoldt M, Riedel C, Braeunig J, et al.

  Stroke volume determination using transcardiopulmonary thermodilution and arterial pulse contour analysis in severe aortic valve disease.

  Intensive Care Med. 2013;39:601–611

Kinetic therapy (e.g. prone positioning)

Research shows that the EVLW can be used to demonstrate the positive effect of laying the patient in a prone position. It has also been shown that the calibrated PiCCO is more accurate than non-calibrated systems.

- Grensemann J, Bruecken U, Treszl A, Wappler F, Sakka SG.

  The influence of prone positioning on the accuracy of calibrated and uncalibrated pulse contour-derived cardiac index measurements.

  Anesth Analg. 2013;116(4):820-826

- Brücken U, Grensemann J, Wappler F, Sakka SG.

  Influence of prone positioning on the measurement of transpulmonary thermodilution-derived variables in critically ill patients.

  Acta Anaesthesiol Scand. 2011;55(9):1061-1067

- Michelet P, Roch A, Gainnier M, Sainty JM, Auffray JP, Papazian L.

  Influence of support on intra-abdominal pressure, hepatic kinetics of indocyanine green and extravascular lung water during prone positioning in patients with ARDS: a randomized crossover study.

  Crit Care. 2005;9(3):R251

Effect of pleural effusion on ELWI

Pleural fluid does not affect the EVLWI measurement. The capillary surface of the lung parenchyma that is in contact with the pleural fluid is very small in comparison to the pulmonary capillary network. Temperature loss to pleural fluid is also negligible.

- Deeren D, Dits H, Daelemans R, Malbrain ML.

  Effect of pleural fluid on the measurement of extravascular lung water by single transpulmonary thermodilution.

  Clinical Intensive Care. 2004;15:119-22

Effect of pulmonary embolism on ELWI

In pulmonary embolism, due to an obstruction in the pulmonary vasculature, EVLW is underestimated. Despite this, in this case the cardiac output and the global end-diastolic volume (GEDV) are still measured correctly.

- Schreiber T, Hüter L, Schwarzkopf K, et al.

  Lung perfusion affects preload assessment and lung water calculation with the transpulmonary double indicator method.

  Intensive Care Med. 2001;27(11):1814-1818

Therapies

Hypothermia

There is no influence on the thermodilution measurements as long as the patient's temperature is stable. Cooled injectate should be used.

- Demirgan S, Erkalp K, Sevdi MS, et al.

  Cardiac condition during cooling and rewarming periods of therapeutic hypothermia after cardiopulmonary resuscitation.

  BMC Anesthesiol. 2014;14:78

- Tagami T, Kushimoto S, Tosa R, et al.

  The precision of PiCCO® measurements in hypothermic post-cardiac arrest patients.

  Anaesthesia. 2012;67(3):236-243

Vasoconstrictor and/or inotrope therapy

All parameters are correctly calculated. In case of significant changes in catecholamines or volume therapy, recalibration of the pulse contour analysis is recommended.

- Gruenewald M, Meybohm P, Renner J, et al.

  Effect of norepinephrine dosage and calibration frequency on accuracy of pulse contour-derived cardiac output.

  Crit Care. 2011;15(1):R22

- Hamzaoui O, Monnet X, Richard C, Osman D, Chemla D, Teboul JL.

  Effects of changes in vascular tone on the agreement between pulse contour and transpulmonary thermodilution cardiac output measurements within an up to 6-hour calibration-free period.

  Crit Care Med. 2008;36(2):434-440

Intra-aortic Balloon Pump (IABP)

The thermodilution measurement with PiCCO is not influenced by the IABP, but the pulse contour analysis is usually unable to provide valid continuous cardiac output and related parameters.

- Schmid B, Fink K, Olschewski M, et al.

  Accuracy and precision of transcardiopulmonary thermodilution in patients with cardiogenic shock.

  J Clin Monit Comput. 2016 Dec;30(6):849-856. Epub 2015 Oct 1.

- Janda M, Scheeren TWL, Bajorat J, et al.

  The impact of intra-aortic balloon pumping on cardiac output determination by pulmonary arterial and transpulmonary thermodilution in pigs.

  J of Cardiovasc and Vasc Anesth. 2006;20(3):320-324

Extracorporeal membrane oxygenation (ECMO), extracorporeal lung assist (ECLA)

In an observational study in patients with veno-venous extra-corporeal membrane oxygenation (ECMO) the PiCCO thermodilution measurement results for cardiac index were not significantly affected by the ECMO, providing accurate calibration of pulse contour analysis and reliable results for all continuous readings. In contrast, the results for global end-diastolic index (GEDI) and extravascular lung water index (ELWI) were significantly increased during the running vv-ECMO. Effects of a veno-arterial ECMO have not be investigated yet.

- Herner A, Lahmer T, Mayr U, et al.

  Transpulmonary thermodilution before and during veno-venous extra-corporeal membrane oxygenation ECMO: an observational study on a potential loss of indicator into the extra-corporeal circuit.

  J Clin Monit Comput 2019;
  DOI: 10.1007/s10877-019-00398-6

Ventricular assist device (VAD)

With a right ventricular assist device the PiCCO thermodilution measurement has been shown to work.

- Wiesenack C, Prasser C, Liebold A, Schmid FX.

  Assessment of left ventricular cardiac output by arterial thermodilution technique via a left atrial catheter in a patient on a right ventricular assist device.

  Perfusion. 2004;19(1):73-75

Continuous renal replacement therapy (CRRT), hemofiltration, dialysis

PiCCO measurement results are accurate when the following criteria are fulfilled:

- PiCCO thermodilution measurements should not be taken directly after the CRRT is switched on or off
- A stable blood temperature baseline needs to be achieved before performing PiCCO measurements
- The CRRT catheter out- and inflow should not lie in the PiCCO indicator passage track

- Geith S, Stecher L, Rabe C, Sack S, Eyer F.

  Sustained low efficiency dialysis should not be interrupted for performing transpulmonary thermodilution measurements.

  Ann Intensive Care. 2018;8:113
  DOI: 10.1186/s13613-018-0455-x

- Pathil A, Stremmel W, Schwenger V, Eisenbach C.

  The influence of haemodialysis on haemodynamic measurements using transpulmonary thermodilution in patients with septic shock: an observational study.

  Eur J Anaesthesiol. 2013;30(1):16-20

- Dufour N, Delville M, Teboul JL, et al.

  Transpulmonary thermodilution measurements are not affected by continuous veno-venous hemofiltration at high blood pump flow.

  Intensive Care Med. 2012;38(7):1162-1168

- Heise D, Faulstich M, Morer O, Brauer, Quintel M.

  Influence of continuous renal replacement therapy on cardiac output measurement using thermodilution techniques.

  Minerva Anestesiol. 2012;78(3):315-321

- Sakka S, Hanusch T, Thuemer, Wegscheider K.

  The influence of venovenous renal replacement therapy on measurements by the transpulmonary thermodilution technique.

  Anesth Analg. 2007;105(4):1079-1082

Effect of lung resection on ELWI

Lung resection procedures (lobectomy, bilobectomy, pneumectomy) theoretically reduce the pulmonary blood volume (PBV) and may lead to an underestimation of the extravascular lung water (EVLW). To evaluate this theoretical assumption, a double indicator dilution technique is required to determine PBV before and after lung resection. Clinical studies using this approach show that:

- The amount of extracted lung tissue and pulmonary blood volume do not correlate
- Clear correction factors for PBV calculation cannot be determined
- An initial effect on PBV is widely physiologically compensated, two days post-operatively at the latest

Thus, it is not recommended to correct the measured values for PBV and EVLW with fixed calculation factors. Clinical evidence is not available for this action. Such corrections may lead to unexpected and unpredictable errors in the calculation of EVLW in patients after lung resection.

- Naidu BV, Dronavalli VB, Rajesh PB.

  Measuring lung water following major lung resection.

  Interact CardioVasc Thorac Surg. 2009;8:503-506

- Schroder C, Kuhn K, Macchiarini P.

  Radical lymphadenectomy does not effect intrathoracic fluid volume changes after lung surgery.

  Internet J Thorac Cardiovasc Surg. 2005;7(2)

Magnetic resonance imaging (MRI)

The effect of MRI on the PiCCO catheter has been investigated as observational study with survey analysis and in model experiments and published as congress poster abstracts. These investigations do not report any negative effects on the functionality of the PiCCO Catheter during MRI. However, there are currently no systematic tests for all available MRI systems under various measurement conditions. Therefore PULSION cannot confirm the compatibility of the PiCCO catheter with MRI systems and must recommend the removal of the PiCCO catheter before MRI. It is the treating physician's full responsibility for the decision to leave the PiCCO Catheter in the patient during the MRI.

- Huber W, Minning A, Sakka S, et al.

  Is magnetic resonance imaging (MRI) feasible with an indwelling transpulmonary thermodilution catheter: data from an observational analysis and from a survey.

  Intensive Care Medicine Experimental 2015, 3(Suppl 1):A612

- Greco F, Vendrell JF, Deras P, Boularan A, Perrigault PF.

  [The Pulsiocath catheter and magnetic resonance imaging.]

  Ann Fr Anesth Reanim 2011;30(9):697

- Kampen J, Liess C, Casadio C, Tonner PH, Reuter M, Scholz J.

  Safety of the Pulsiocath for haemodynamic monitoring during magnetic resonance imaging.

  Anaesthesia. 2004;59(8):828-829

- Kampen J, Liess K, Casadio C, Tonner PH, Scholz J.

  [Thermal lesions caused by a PiCCO catheter left in place in the MRT? – Fibre optical measurements of temperature in a No-flow-model.]

  Intensivmedizin und Notfallmedizin. 2002;39:113

Passive leg raising (PLR)

The PiCCO has been used in several investigations to show if a patient is volume responsive using passive leg raising.

- Guerin L, Teboul JL, Persichini R, Dres M, Richard C, Monnet X.

  Effects of passive leg raising and volume expansion on mean systemic pressure and venous return in shock in humans.

  Crit Care. 2015;19:411

- Jabot J, Teboul JL, Richard C, Monnet X.

  Passive leg raising for predicting fluid responsiveness: importance of the postural change.

  Intensive Care Med. 2009;35(1):85-90

Clinical significance of PiCCO parameters

Global end-diastolic volume index (GEDI) as an indicator of cardiac preload

Strictly defined, cardiac preload is the myocardial fibre stretch at the end of ventricular diastole. A parameter that accurately reflects preload in clinical practice is not yet available. However, studies have demonstrated that GEDI (or ITBI) is a reproducible and sensitive parameter and a good approximation of preload.

- Umgelter A, Wagner K, Reindl W, Nurtsch N, Huber W, Schmid RM.

  Hemodynamic effects of plasma-expansion with hyperoncotic albumin in cirrhotic patients with renal failure: a prospective interventional study.

  BMC Gastroenterol. 2008;8(1):39

- Sander M, Spies CD, Berger K, et al.

  Prediction of volume response under open-chest conditions during coronary artery bypass surgery.

  Crit Care. 2007;11(6):R121

- Michard F, Alaya S, Zarka V, Bahloul M, Richard C, Teboul JL.

  Global end-diastolic volume as an indicator of cardiac preload in patients with septic shock.

  Chest. 2003;124(5):1900-1908

- Della Rocca G, Costa GM, Coccia C, Pompei L, Di Marco P, Pietropaoli P.

  Preload index: pulmonary artery occlusion pressure versus intrathoracic blood volume monitoring during lung transplantation.

  Anesth Analg. 2002;95(4):835-843

Fluid responsiveness by stroke volume variation (SVV) and pulse pressure variation (PPV)

The following requirements have to be fulfilled:

- Fully controlled mechanical ventilation with a tidal volume ≥ 8 ml/kg PBW (predicted body weight)
- Sinus rhythm
- Pressure curves free of artifacts

- Hofer CK, Muller SM, Furrer L, Klaghofer R, Genoni M, Zollinger A.

  Stroke volume and pulse pressure variation for prediction of fluid responsiveness in patients undergoing off-pump coronary artery bypass grafting.

  Chest. 2005;128(2):848-854

- Reuter DA, Kirchner A, Felbinger TW, et al.

  Usefulness of left ventricular stroke volume variation to assess fluid responsiveness in patients with reduced cardiac function.

  Crit Care Med. 2003;31(5):1399-1440

Validity and clinical relevance of the PiCCO Technology contractility parameters

The PiCCO Technology offers several contractility related parameters like the intermittent cardiac function index (CFI) and global ejection fraction (GEF) as well as the continuous left ventricular contractility (dPmx). The cardiac power index (CPO/CPI) can be considered a contractility parameter, even though it is usually classified as an organ function (cardiac) parameter.

- Meybohm P, Gruenewald M, Renner J, et al.

  Assessment of left ventricular systolic function during acute myocardial ischemia: a comparison of transpulmonary thermodilution and transesophageal echocardiography.

  Minerva Anestesiol. 2011;77(2):132-141

- Trepte CJ, Eichhorn V, Haas SA, et al.

  Thermodilution-derived indices for assessment of left and right ventricular cardiac function in normal and impaired cardiac function.

  Crit Care Med. 2011;39(9):2106-2112

- Combes A, Berneau JB, Luyt CE, Trouillet JL.

  Estimation of left ventricular systolic function by single transpulmonary thermodilution.

  Intensive Care Med. 2004;30:1377-1383

Cardiac function index (CFI)

- Perny J, Kimmoun A, Perez P, Levy B.

  Evaluation of cardiac function index as measured by transpulmonary thermodilution as an indicator of left ventricular ejection fraction in cardiogenic shock.

  Biomed Res Int 2014;2014:598029.

- Jabot J, Monnet X, Bouchra L, Chemla D, Richard C, Teboul JL.

  Cardiac function index provided by transpulmonary thermodilution behaves as an indicator of left ventricular systolic function.

  Crit Care Med 2009;37(11):2913-2918

- Ritter S, Rudiger A, Maggiorini M.

  Transpulmonary thermodilution-derived cardiac function index identifies cardiac dysfunction in acute heart failure and septic patients: an observational study.

  Critical Care. 2009;13:R133

Left ventricular contractility (dPmx)

- De Hert SG, Robert D, Cromheecke S, Michard F, Nijs J, Rodrigus IE.

  Evaluation of left ventricular function in anesthetized patients using femoral artery dP/dtmax.

  J Cardiothorac Vasc Anesth. 2006;20(3):325-330

Cardiac power (CPO/CPI)

The cardiac power output/index (CPO/CPI) has been investigated in the past in patients with heart failure. It has been found that cardiac power is a direct indicator of the overall cardiac function and is the strongest independent predictor of in-hospital mortality in patients with cardiogenic shock. CPI is established as one of the target parameters in the German-Austrian S3 Guideline on diagnosis, monitoring and treatment of cardiogenic shock patients (Werdan et al., Dtsch Arztebl Int 2012).

- Werdan K, Ruß M, Buerke M, Delle-Karth G, Geppert A, Schöndube FA.

  Cardiogenic shock due to myocardial infarction: Diagnosis, monitoring and treatment.

  Dtsch Arztebl Int. 2012;109(19):343-351

- Mendoza DD, Cooper HA, Panza JA.

  Cardiac power output predicts mortality across a broad spectrum of patients with acute cardiac disease.

  Am Heart J. 2007;153(3):366-370

- Fincke R, Hochman JS, Lowe AM, et al.

  Cardiac power is the strongest hemodynamic correlate of mortality in cardiogenic shock: a report from the SHOCK trial registry.

  J Am Coll Cardiol. 2004;21;44(2):340-348

- Cotter G, Williams SG, Vered Z, Tan LB.

  Role of cardiac power in heart failure.

  Curr Opin Cardiol. 2003;18(3):215-222

Weaning from the ventilator

- Dres M, Teboul JL, Anguel N, Guerin L, Richard C, Monnet X.

  Passive leg raising performed before a spontaneous breathing trial predicts weaning-induced cardiac dysfunction.

  Intensive Care Med. 2015;41:487-494

- Redondo Calvo FJ, Bejarano Ramirez N, Una Orejon R, Villazala Garcia R, Yuste Pena AS, Belda FJ.

  Elevated extravascular lung water index (ELWI) as a predictor of failure of continuous positive airway pressure via helmet (Helmet-CPAP) in patients with acute respiratory failure after major surgery.

  Arch Bronconeumol. 2015;51(11):558-563

- Dres M, Teboul JL, Monnet X.

  Weaning the cardiac patient from mechanical ventilation.

  Curr Opin Crit Care. 2014;(5):493-498

Accuracy of chest x-ray for measuring pulmonary oedema

Research confirms that presently, it is not possible to quantify the extent of pulmonary edema with a chest x-ray. The interpretation of a chest x-ray is complex since it is a density measurement and influenced by all compartments in the chest, like bones, muscles, vessels, blood, air, skin layers, tissue edema, pleural effusion and, amongst the others, also by the extravascular lung water.

- Brown LM, Calfee CS, Howard JP, Craig TR, Matthay MA, McAuley DF.

  Comparison of thermodilution measured extravascular lung water with chest radiographic assessment of pulmonary oedema in patients with acute lung injury.

  Ann Intensive Care. 2013;3(1):25

- Saugel B, Ringmaier S, Holzapfel K, et al.

  Physical examination, central venous pressure, and chest radiography for the prediction of transpulmonary thermodilution-derived hemodynamic parameters in critically ill patients: a prospective trial.

  J Crit Care. 2011;26(4):402-410

- Lemson J, van Die LE, Hemelaar AE, van der Hoeven JG.

  Extravascular lung water index measurement in critically ill children does not correlate with a chest x-ray score of pulmonary edema.

  Crit Care. 2010;14(3):R105

Quantification of pulmonary edema by the measurement of extravascular lung water index (ELWI)

The PiCCO Technology offers direct and accurate bedside quantification of pulmonary edema by the measurement of extravascular lung water index (ELWI). This enables a sensitive and early detection of the development of pulmonary edema and thus an early therapeutic intervention before pulmonary edema can cause alveolar damage and other complications. It is also an early predictor of acute respiratory distress syndrome (ARDS) and enables an improved classification of origin and severity.

- Jozwiak M, Teboul JL, Monnet X.

  Extravascular lung water in critical care: recent advances and clinical applications.

  Ann Intensive Care. 2015;5(1):38

- Kor DJ, Warner DO, Carter RE, et al.

  Extravascular lung water and pulmonary vascular permeability index as markers predictive of post-operative acute respiratory distress yyndrome: a prospective cohort investigation.

  Crit Care Med. 2015;43(3):665-673

- Morisawa K, Fujitani S, Taira Y, et al.

  Difference in pulmonary permeability between indirect and direct acute respiratory distress syndrome assessed by the transpulmonary thermodilution technique: a prospective, observational, multi-institutional study.

  J Intensive Care. 2014;2(1):24

- Kushimoto S, Endo T, Yamanouchi S, et al.

  Relationship between extravascular lung water and severity categories of acute respiratory distress syndrome by the Berlin definition.

  Crit Care. 2013;17(4):R132

- Jozwiak M, Silva S, Persichini R, et al.

  Extravascular lung water is an independent prognostic factor in patients with acute respiratory distress syndrome.

  Crit Care Med. 2013;41(2):472-480

- Tagami T, Sawabe M, Kushimoto S, et al.

  Quantitative diagnosis of diffuse alveolar damage using extravascular lung water.

  Crit Care Med. 2013;41(9):2144-2150

- LeTourneau JL, Pinney J, Phillips CR.

  Extravascular lung water predicts progression to acute lung injury in patients with increased risk.

  Crit Care Med. 2012;40(3):8478-8454

- Berkowitz DM, Danai PA, Eaton S, Moss M, Martin G.

  Accurate characterization of extravascular lung water in acute respiratory distress syndrome.

  Crit Care Med. 2008;36(6):1803-1809

- Monnet X, Anguel N, Osman D, Hamzaoui, Richard C, Teboul JL.

  Assessing pulmonary permeability by transpulmonary thermodilution allows differentiation of hydrostatic pulmonary edema from ALI/ARDS.

  Intensive Care Med. 2007;33(3):448-453

Outcome improvement in ARDS patients

ARDS patient management based on the PiCCO Technology parameter of ELWI resulted in shorter ventilation time, better oxygenation index and improved survival.

- Hu W, Lin CW, Liu BW, Hu WH, Zhu Y.

  Extravascular lung water and pulmonary arterial wedge pressure for fluid management in patients with acute respiratory distress syndrome.

  Multidiscip Respir Med. 2014;9(1):3

- Tagami T, Nakamura T, Kushimoto S, et al.

  Early-phase changes of extravascular lung water index as a prognostic indicator in acute respiratory distress syndrome patients.

  Ann Intensive Care. 2014;4:27

- Craig TR, Duffy MJ, Shyamsundar M, et al.

  Extravascular lung water indexed to predicted body weight is a novel predictor of intensive care unit mortality in patients with acute lung injury.

  Crit Care Med. 2010;38(1):114-120

- Phillips CR, Chesnutt MS, Smith SM.

  Extravascular lung water in sepsis-associated acute respiratory distress syndrome: indexing with predicted body weight improves correlation with severity of illness and survival.

  Crit Care Med. 2008;36(1):69-73

Pulmonary vascular permeability index (PVPI) for differential diagnosis of pulmonary edema origin

In case of diagnosed pulmonary edema (high ELWI), the parameter of pulmonary vascular permeability index (PVPI) enables a differential diagnosis of its origin. Based on clinical studies, a PVPI value of less than 3 most likely indicates cardiogenic pulmonary edema (left heart failure, fluid overload) whereas a PVPI value 3 or above indicates pulmonary edema most likely due to permeability damage (sepsis, ARDS).

- Jozwiak M, Teboul JL, Monnet X.

  Extravascular lung water in critical care: recent advances and clinical applications.

  Ann Intensive Care. 2015;5(1):38

- Garutti I, Sanz J, Olmedilla L, et al.

  Extravascular Lung Water and Pulmonary Vascular Permeability Index Measured at the End of Surgery Are Independent Predictors of Prolonged Mechanical Ventilation in Patients Undergoing Liver Transplantation.

  Anesth Analg. 2015;121(3):736-745

- Kor DJ, Warner DO, Carter RE, et al.

  Extravascular Lung Water and Pulmonary Vascular Permeability Index as Markers Predictive of Postoperative Acute Respiratory Distress Syndrome: a Prospective Cohort Investigation.

  Crit Care Med. 2014;43(3):665-673

- Morisawa K, Fujitani S, Taira Y, et al.

  Difference in pulmonary permeability between indirect and direct acute respiratory distress syndrome assessed by the transpulmonary thermodilution technique: a prospective, observational, multi-institutional study.

  J Intensive Care. 2014;2:24

- Kushimoto S, Taira Y, Kitazawa Y, et al.

  The clinical usefulness of extravascular lung water and pulmonary vascular permeability index to diagnose and characterize pulmonary edema: a prospective multicenter study on the quantitative differential diagnostic definition for acute lung injury/acute respiratory distress syndrome.

  Crit Care. 2012;16(6):R232

- Monnet X, Anguel N, Osman D, Hamzaoui O, Richard C, Teboul JL.

  Assessing pulmonary permeability by transpulmonary thermodilution allows differentiation of hydrostatic pulmonary edema from ALI / ARDS.

  Intensive Care Med. 2007

Outcome studies

Hemodynamic monitoring itself is not able to improve outcome. However, when the hemodynamic variables are used in a clearly defined treatment algorithm to manage individualized goal-directed therapy, there is a high potential for an improvement in outcome. Several studies have already confirmed improved outcome when PiCCO parameters are used to apply therapy for hemodynamic optimization in critically ill patients.

- Yuanbo Z, Jin W, Fei S, et al.

  ICU management based on PiCCO parameters reduces duration of mechanical ventilation and ICU length of stay in patients with severe thoracic trauma and acute respiratory distress syndrome.

  Ann Intensive Care. 2016;6:113

- Mutoh T, Kazumata K, Terasaka S, Taki Y, Suzuki A, Ishikawa T.

  Early Intensive Versus Minimally Invasive Approach to Postoperative Hemodynamic Management After Subarachnoid Hemorrhage.

  Stroke. 2014;45(5):1280-1284

- Hu W, Lin CW, Liu BW, Hu WH, Zhu Y.

  Extravascular lung water and pulmonary arterial wedge pressure for fluid management in patients with acute respiratory distress syndrome.

  Multidiscip Respir Med. 2014;9(1):3

- Goepfert M, Richter HP, Eulenburg CZ, et al.

  Individually Optimized Hemodynamic Therapy Reduces Complications and Length of Stay in the Intensive Care Unit: A Prospective, Randomized Controlled Trial.

  Anesthesiology. 2013;119(4);824-836

- Kraft R, Herndon DN, Branski LK, Finnerty CC, Leonard KR, Jeschke MG.

  Optimized fluid management improves outcomes of pediatric burn patients.

  J Surg Res. 2013;181(1):121-128

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

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

  Acta Anaesthesiol Scand. 2008;52(6):742-749

Technique & technology questions

Risk profile of PiCCO femoral catheter versus other arterial catheters

Evidence shows there is no additional risk when using any of the PiCCO arterial catheters when compared to standard arterial lines.

- Belda FJ, Aguilar G, Teboul JL, et al.

  Complications related to less-invasive haemodynamic monitoring.

  Br J Anaesth. 2011;106:482-486

- Scheer BV, Perel A, Pfeiffer UJ.

  Clinical review: Complications and risk factors of peripheral arterial catheters used for haemodynamic monitoring in anaesthesia and intensive care medicine.

  Critical Care. 2002;6(3):198-204

PiCCO measurements from a standard short radial artery catheter is not possible

In critically ill patients the arterial pressure waveform at the radial site is affected by vascular tone (vasoconstriction and dilation) and compliance, making arterial blood pressure measurements inaccurate. Also, due to the distance involved, it is not possible to record the downstream temperature required for the thermodilution measurement.

- Camporota L and Beale R.

  Pitfalls in haemodynamic monitoring based on the arterial pressure waveform.

  Crit Care. 2010;14(2):124

- Orme RMLE, Pigott DW, Mihm FG.

  Measurement of cardiac output by transpulmonary arterial thermodilution using a long radial artery catheter. A comparison with intermittent pulmonary artery thermodilution.

  Anaesthesia. 2004;59:590-594

How many thermodilution measurements are recommended?

It is recommend that three consecutive measurements, with less than 15% (+/-) variation compared to the mean value are performed within a 10 minute time frame.

- Giraud R, Siegenthaler N, Merlani P, Bendjelid K.

  Reproducibility of transpulmonary thermodilution cardiac output measurements in clinical practice: a systematic review.

  J Clin Monit Comput. 2016

- Monnet X, Persichini R, Ktari M, Jozwiak M, Richard C, Teboul JL.

  Precision of the transpulmonary thermodilution measurements.

  Crit Care. 2011;15(4):R204

Considerations in case of thermodilution injection into the femoral vein and the PiCCO catheter placed in the femoral artery

If both the central venous catheter and PiCCO arterial catheters are placed on the same side (e.g. right femoral groin), the injectate may be detected immediately through the vessel wall (cross talk phenomena) resulting in measurement errors. This is more common in pediatric patients.

- Lemson J, Eijk RJ, van der Hoeven JG.

  The "cross-talk phenomenon" in transpulmonary thermodilution is flow dependent.

  Intensive Care Med. 2006;32(7):1092

Cross talk can be avoided if the PiCCO arterial catheter is either placed in the opposite femoral artery or in the brachial / axillary artery. If placed femoral, thermodilution measurement is possible. PiCCO preload value and global end-diastolic volume (GEDI) will be slightly higher than the actual volume. The $PiCCO_2$ software version V3.1 (and later versions) a confirmation of where both the central venous and arterial catheters are placed is asked, to ensure accurate calculation of GEDI.

- Saugel B, Umgelter A, Schuster T, Phillip V, Schmid RM, Huber W.

  Transpulmonary thermodilution using femoral indicator injection: a prospective trial in patients with a femoral and a jugular central venous catheter.

  Crit Care. 2010;14:R95

- Schmidt S, Westhoff TH, Hofmann C, et al.

  Effect of the venous catheter site on transpulmonary thermodilution measurement variables.

  Crit Care Med. 2007;35:783-786

Thermodilution injection with a room temperature instead of a cold injectate

Evidence shows that the use of room temperature injectate may not be as accurate. Therefore, particularly in patients with elevated lung water, the use of cold injectate is recommended.

- Huber W, Kraski T, Haller B, et al.

  Room-temperature vs iced saline indicator injection for transpulmonary thermodilution.

  J Crit Care. 2014;29(6):1133e7-1133e14

Frequency of thermodilution injections to recalibrate continuous cardiac output

In general, the PiCCO should be calibrated every 8 hours by thermodilution. However, individual patient needs vary greatly. In case of hemodynamic instability, the pulse contour will deviate from the thermodilution cardiac output. In such cases, frequent recalibration (via thermodilution) is recommended.

- Huber W, Koenig J, Mair S, et al.

  Predictors of the accuracy of pulse-contour cardiac index and suggestion of a calibration-index: a prospective evaluation and validation study.

  BMC Anesthesiol. 2015;15:45

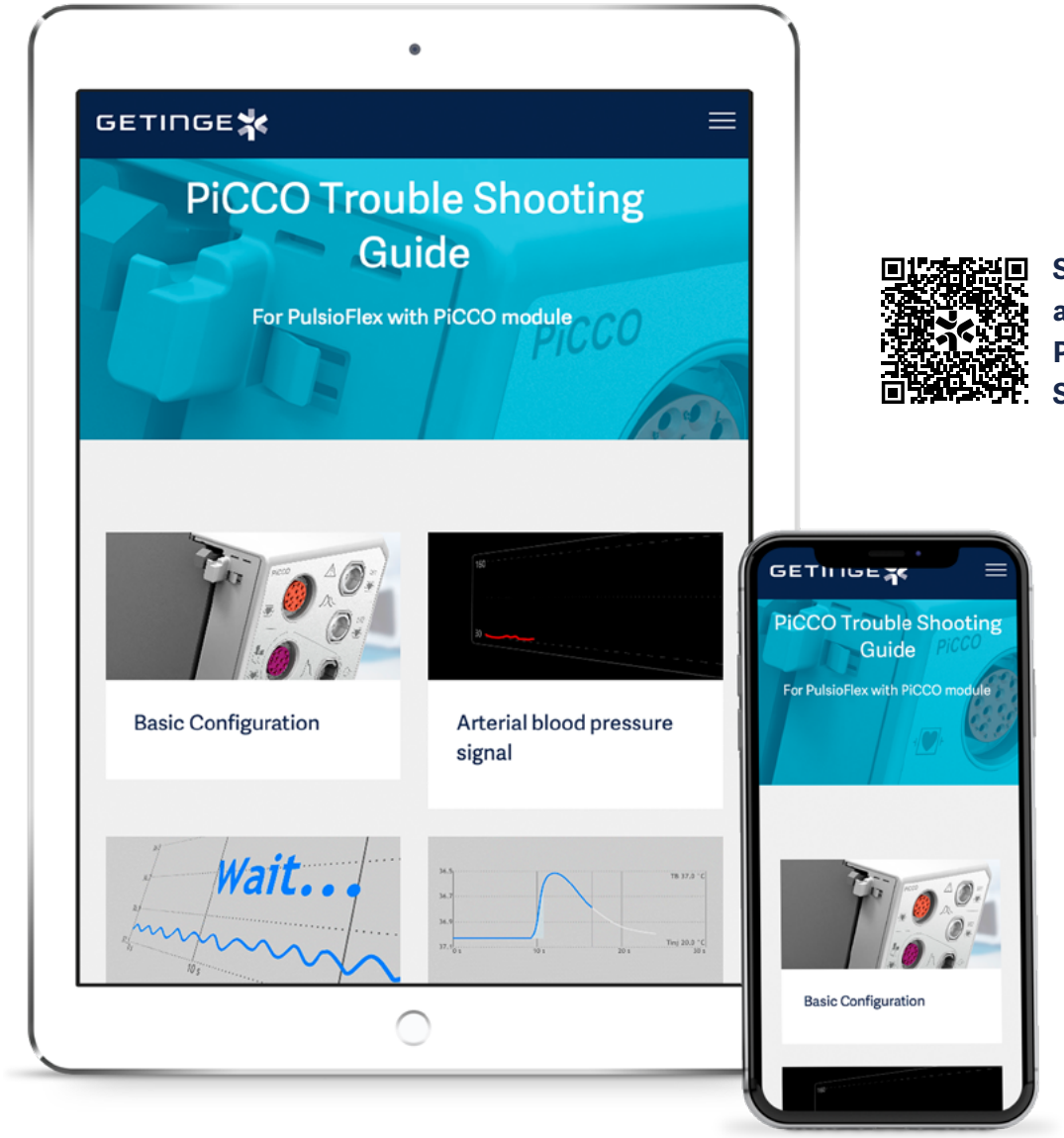
- Hamzaoui O, Monnet X, Richard C, Osman D, Chemla D, Teboul JL.

  Effects of changes in vascular tone on the agreement between pulse contour and transpulmonary thermodilution cardiac output measurements within an up to 6-hour calibration-free period.

  Crit Care Med. 2008;36(2):434-440

PiCCO practical help

Find out how to optimize PiCCO thermodilution measurements in your daily use. Containing comprehensive practical support, the PiCCO Trouble Shooting Guide assists clinicians and technicians when in need for handling information.



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