# PULSION Medical Systems

# PiCCO Technology Literature

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- Very highly recommended
- Highly recommended
- Recommended

‘This document is intended to provide information to an international audience outside of the US’
1. **Reviews**

1.1 **General**

Assaad S, Popescu W, Perrino A  
**Fluid management in thoracic surgery**  
Curr Opin Anaesthesiol 2013; 26(1): 31-9

Sakka SG, Reuter DA, Perel A  
**The transpulmonary thermodilution technique**  
J Clin Monit Comput 2012; 26: 347-53

Oren-Grinberg A.  
**The PiCCO Monitor**  
International Anesthesiology Clinics 2010; 48(1): 57 – 85

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

King D & Price AM.  
**Measuring cardiac output using the PiCCO system**  
British Journal of Cardiac Nursing 2008; 3 (11): 512-519

Malbrain M, De Potter P, Deeren D.  
**Cost Effectiveness of minimally invasive hemodynamic monitoring**  

Genahr A, McLuckie A  
**Transpulmonary thermodilution in the critically ill**  
Brit J Int Care 2004: 6-10

1.2 **Cardiac Output**

Reuter D, Goetz AE  
**[Messung des Herzzeitvolumens]** (Article in German)  
Anaesthesist 2005; 54:1135-53

1.3 **Preload**

Eichhorn V, Goepfert MS, Eulenburg C, Malbrain ML, Reuter DA  
**Comparison of values in critically ill patients for global end-diastolic volume and extravascular lung water measured by transcardiopulmonary thermodilution: A metaanalysis of the literature**  
Med Intensiva 2012; 36(7): 467-74

Della Rocca G, Costa MG, Pietropaoli P.  
**How to measure and interpret volumetric measures of preload**  
Curr Opin Crit Care 2007; 13(3): 297-302
1.4 Lung Water
Zhang Z, Lu B, Ni H.
Prognostic value of extravascular lung water index in critically ill patients: A systematic review of the literature
J Crit Care 2012; 27(4): 420 e.1-9

Maharaj R.
Extravascular lung water and acute lung injury
Cardiol Res Pract 2011; 2012: 407035

Fernandez-Mondejar E, Guerrero-López F, Colmenero M.
How important is the measurement of extravascular lung water?
Curr Opin Crit Care 2007; 13: 79-83

Michard F.
Bedside assessment of extravascular lung water by dilution methods: temptations and pitfalls

Isakow W, Schuster DP.
Extravascular lung water measurements and hemodynamic monitoring in the critically ill: bedside alternatives to the pulmonary artery catheter
Am J Physiol Lung Cell Mol Physiol 2006; 291: 1118-33

1.5 Pediatric
Lemson J, Nusmeier A, van der Hoeven JG
Advanced Hemodynamic Monitoring in Critically Ill Children
Pediatrics 2011; 128(3): 560-71

2. Guidelines and Standard Operating Procedures
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)]
Anaesthesist 2010; 59(4): 347-70

S3 guidelines for intensive care in cardiac surgery patients: hemodynamic monitoring and cardiocirculatory system
Ger Med Sci 2010; 8: Doc12 (article in German)

2007 American College of Critical Care Medicine clinical practice parameters for hemodynamic support of pediatric and neonatal septic shock
3. Outcome papers

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**
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**Early Intensive Versus Minimally Invasive Approach to Postoperative Hemodynamic Management After Subarachnoid Hemorrhage**
Stroke 2014; 45(5): 1280-4
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**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
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**Individually Optimized Hemodynamic Therapy Reduces Complications and Length of Stay in the Intensive Care Unit: A Prospective, Randomized Controlled Trial**
Anesthesiology 2013; 119(4); 824-36
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**Optimized fluid management improves outcomes of pediatric burn patients**
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Adler C, Reuter H, Seck C, Hellmich M, Zobel C
**Fluid therapy and acute kidney injury in cardiogenic shock after cardiac arrest**
Resuscitation 2013; 84(2): 194-9
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Lenkin AI, Kirov MY, Kuzkov VV, Paromov KV, Smetkin AA, Lie M, Bjertnaes LJ
**Comparison of goal-directed hemodynamic optimization using pulmonary artery catheter and transpulmonary thermodilution in combined valve repair: a randomized clinical trial**
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**Influence of extravascular lung water determination in fluid and vasoactive therapy**  
J Trauma 2009; 67(6): 1220-4  
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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  
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Smetkin AA, Kirov M, Kuzkov VV, Lenkin AI, Ereemeev AV, Slastilin VY, Borodin VV, Bjertnaes LJ.  
**Single transpulmonary thermodilution and continuous monitoring of central venous oxygen saturation during off-pump coronary surgery.**  
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Csontos C, Foldi V, Fischer T, Bogar L.  
**Arterial thermodilution in burn patients suggests a more rapid fluid administration during early resuscitation.**  
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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  
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Mitchell JP, Schuller D, Calandrino FS, Schuster DP.  
**Improved outcome based on fluid management in critically ill patients requiring pulmonary artery catheterization**  
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4a  **PiCCO PARAMETERS – METHODOLOGY**

4a.1  **FLOW (Cardiac Output)**  
Smith JA, Camporota L, Beale R  
**Monitoring arterial blood pressure and cardiac output using central or peripheral arterial pressure waveforms**  
Yearbook of Intensive and Emergency Medicine 2009; 285 - 296  
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Segal E, Katzenelson R, Berkenstadt H, Perel A.  
**Transpulmonary thermodilution cardiac output measurement using the axillary artery in critically ill patients**  
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Sakka SG, Meier-Hellmann A.  
**Evaluation of cardiac output and cardiac preload**  
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4a.2  PRELOAD (Global End Diastolic Volume and Intrathoracic Blood Volume)
Volumetric preload measurement by thermodilution: a comparison with transoesophageal echocardiography
Br J Anaesth 2005; 94(6) 748-55

Buhre W, Buhre K, Kazmaier S, Sonntag H, Weyland A.
Assessment of cardiac preload by indicator dilution and transoesophageal echocardiography
Eur J Anaesthesiol 2001; 18(10): 662-7

McLuckie A, Bihari D.
Investigating the relationship between intrathoracic blood volume index and cardiac index
Intensive Care Med 2000; 26(9): 1376-8

4a.3  CONTRACTILITY (Global Ejection Fraction, Cardiac Function Index and Left Ventricular Contractility)
Michard F, Perel A.
Management of circulatory and respiratory failure using less invasive hemodynamic monitoring
In: Vincent JL (Ed.), Yearbook of Intensive Care and Emergency Medicine 2003; 508-20

Evaluation of the cardiac function index as a new bedside indicator of cardiac performance
Intensive Care Med 1994; 20(S2):21

4a.4  VOLUME RESPONSIVENESS (Stroke Volume Variation and Pulse Pressure Variation)
Reuter DA, Goepfert MS, Goresch T, Schmoekel M, Kilger E, Goetz AE.
Assessing fluid responsiveness during open chest conditions
Br J Anaesth 2005; 94(3): 318-23

Prediction of fluid responsiveness in patients during cardiac surgery
Br J Anaesth 2004; 93(6): 782-8

Reuter DA, Felbinger TW, Kilger E, Schmidt C, Lamm P, Goetz AE.
Optimizing fluid therapy in mechanically ventilated patients after cardiac surgery by on-line monitoring of left ventricular stroke volume variations. Comparison with aortic systolic pressure variations
Br J Anaesth 2002; 88(1): 124-6

4a.5  PULMONARY OEDEMA (Extravascular Lung Water)
Phillips C, Chesnutt M, Smith M.
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
Sakka SG, Klein M, Reinhart K, Meier-Hellmann A.
Prognostic value of extravascular lung water in critically ill patients
Chest 2002; 122(6): 2080-6

4b       PICCO PARAMETERS – VALIDATION

4b.1     FLOW (Cardiac Output)
Calbet JA and Boushel RC
Assessment of cardiac output with transpulmonary thermodilution during exercise in man

Petzoldt M, Riedel C, Braeunig J, Haas S, Goepfert MS, Treede H, Baldus S, Goetz AE, Reuter DA
Stroke volume determination using transcardiopulmonary thermodilution and arterial pulse contour
analysis in severe aortic valve disease

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

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

Lemson J, de Boode WP, Hopman JC, Singh SK, van der Hoeven JG
Validation of transpulmonary thermodilution cardiac output measurement in a pediatric animal model

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

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):129-34

Comparison of esophageal Doppler, pulse contour analysis, and real-time pulmonary artery thermodilution
for the continuous measurement of cardiac output
4b.2 **PRELOAD (Global Enddiastolic Volume and Intrathoracic Blood Volume)**


*Global End-Diastolic Volume as a Variable of Fluid Responsiveness During Acute Changing Loading Conditions*

J Cardiotorac Vasc Anesth 2007; 21(5): 650-4

Kozieras, J, Thuemer O, Sakka SG

*Influence of an acute increase in systemic vascular resistance on transpulmonary thermodilution-derived parameters in critically ill patients*

Intensive Care Med 2007; 33:1619-23

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):1900-8

4b.3 **CONTRACTILITY (Global Ejection Fraction, Cardiac Function Index and Left Ventricular Contractility)**

Aguilar G, Belda FJ, Ferrando C, Jover JL

*Assessing the left ventricular systolic function at the bedside: the role of transpulmonary thermodilution-derived indices*

Anesthesiol Res Pract 2011: 927421


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

Minerva Anestesiol 2011; 77(2): 132-41

Trepte CJ, Eichhorn V, Haas SA, Richter HP, Goepfert MS, Kubitz JC, Goetz AE, Reuter DA

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

Crit Care Med 2011; 39(9): 2106-12


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


de Hert S, Robert D, Cromheecke S, Michard F, Nijs J, Rodrigues IE

*Evaluation of Left Ventricular Function in Anesthetised Patients Using Femoral Artery dP/dtmax*

J Cardio Thor Vasc Anes 2006; 20(3): 325-30
Combes A, Berneau JB, Lut CE, Trouillet JL  
Estimation of left ventricular systolic function by single transpulmonary thermodilution  
Intensive Care Med 2004; 30(7): 1377-83  
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4b.4 VOLUME RESPONSIVENESS (Stroke Volume Variation and Pulse Pressure Variation)  
Kubitz JC, Annecke T, Forkl S, Kemming GI, Kronas N, Goetz AE, Reuter DA  
Validation of pulse contour derived stroke volume variation during modifications of cardiac afterload  
Br J Anaesth 2007; 98(5): 591-7  
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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):848-54  
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Reuter DA, Kirchner A, Felbinger TW, Weis FC, Kilger E, Lamm P, Goetz AE  
Usefulness of left ventricular stroke volume variation to assess fluid responsiveness in patients with reduced cardiac function  
Crit Care Med 2003; 31(5):1399-404  
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4b.5 PULMONARY ODEMA (Extravascular Lung Water)  
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  
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Measurement of extravascular lung water following human brain death; implications for lung donor assessment and transplantation  
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Tagami T, Kushimoto S, Yamamoto Y, Atsumi T, Tosa R, Matsuda K, Oyama R, Kawaguchi T, Masuno T, Hirama H, Yokota H  
Validation of extravascular lung water measurement by single transpulmonary thermodilution: human autopsy study  
Crit Care 2010; 14(5): R162  
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Lemson J, Backx AP, van Oort AM, Bouw TP, van der Hoeven JG  
Extravascular lung water measurement using transpulmonary thermodilution in children  
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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  
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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):R451-8

Katzenelson R, Perel A, Berkenstadt H, Preisman S, Kogan S, Sternik L, Segal E
Accuracy of transpulmonary thermodilution versus gravimetric measurement of extravascular lung water
Crit Care Med 2004; 32(7):1550-4

Sakka SG, Ruhl CC, Pfeiffer UJ, Beale R, McLuckie A, Reinhart K, Meier-Hellmann A
Assessment of cardiac preload and extravascular lung water by single transpulmonary thermodilution

5. Fields of Application

5.1 ALI / ARDS
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 - 73

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

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

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

Kushimoto S, Endo T, Yamanouchi S, Sakamoto T, Ishikura H, Kitazawa Y 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

Quantitative Diagnosis of Diffuse Alveolar Damage Using Extravascular Lung Water
Crit Care Med 2013; 41(9); 2144-50
Extravascular lung water is an independent prognostic factor in patients with acute respiratory distress syndrome

Kushimoto S, Taira T, Taira, Y, Kitazawa Y, Okuchi K, Sakamoto T, Ishikura H, Endo T, Yamanouchi S 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

Letourneau JL, Pinney J, Phillips C
Extravascular lung water predicts progression to acute lung injury in patients with increased risk
Crit Care Med 2012; 40(3): 947-54

Craig TR, Duffy MJ, Shyamsundar M, McDowell C, McLaughlin B, Elborn JS, McAuley D
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): 114-20

Berkowitz DM, Danai PA, Eaton S, Moss M, Martin G
Accurate characterization of extravascular lung water in acute respiratory distress syndrome

Phillips C, Chesnutt M, Smith M
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

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

Perkins GD, McAuley DF, Thickett DR, Gao F
The beta-agonist lung injury trial (BALTI): a randomized placebo-controlled clinical trial
Am J Respir Crit Care Med 2006; 173(3): 281-7

5.2 Burns
Sanchez-Sanchez M, Garcia-de-Lorenzo A, Herrero E, Lopez T, Galvan B, Asensio MJ, Cachafeiro L, Casado C
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
Branski LK, Herndon DN, Byrd JF, Kinsky MP, Lee JO, Fagan SP, Jeschke MG
*Transpulmonary thermodilution for hemodynamic measurements in severely burned children*

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: 1263-70

Csontos C, Foldi V, Fischer T, Bogar L
*Arterial thermodilution in burn patients suggests a more rapid fluid administration during early resuscitation*

*Reproducibility of transpulmonary thermodilution measurements in patients with burn shock and hypothermia*

Holm C, Melcer B, Horbrand F, Henckel von Donnersmarck G, Muhlauer W.
*Arterial thermodilution: an alternative to pulmonary artery catheter for cardiac output assessment in burn patients*
Burns 2001; 27(2):161-6

Holm C, Melcer B, Horbrand F, Worl H, von Donnersmarck GH, Muhlauer W.
*Intrathoracic blood volume as an end point in resuscitation of the severely burned: an observational study of 24 patients*
J Trauma 2000; 48(4):728-34

5.3  Cardiac Surgery
*Individually Optimized Hemodynamic Therapy Reduces Complications and Length of Stay in the Intensive Care Unit: A Prospective, Randomized Controlled Trial*
Anesthesiology 2013; 119(4); 824-36

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): 431-7

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

Wouters PF, Quaghebeur B, Sergeant P, Van Hemelrijck J, Vandermeersch E
Cardiac output monitoring using a brachial arterial catheter during off-pump coronary artery bypass grafting

Bettex DA, Hinselmann V, Hellermann JP, Jenni R, Schmid ER
Transoesophageal echocardiography is more unreliable for cardiac output assessment after cardiac surgery
compared with thermodilution
Anesthesia 2004; 59:1184-92

Comparison of continuous cardiac output measurements in patients after cardiac surgery
J Cardiothorac Vasc Anesth 2003; 17(2):211-6

Comparison of cardiac output assessed by pulse-contour analysis and thermodilution in patients undergoing
minimally invasive direct coronary artery bypass grafting

Continuous, less invasive, hemodynamic monitoring in intensive care after cardiac surgery

5.4 Cardiogenic Shock
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: 598029

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

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

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):320-4
5.5 Hypovolemic Shock
Nirmalan M, Niranjan M, Willard T, Edwards JD, Little RA, Dark PM

Estimation of errors in determining intrathoracic blood volume using thermal dilution in pigs with acute lung
injury and haemorrhage

Berkenstadt H, Friedman Z, Preisman S, Keidan I, Livingstone D, Perel A

Pulse pressure and stroke volume variations during severe haemorrhage in ventilated dogs

Friedman Z, Berkenstadt H, Margalit N, Segal E, Perel A

Cardiac output assessed by arterial thermodilution during exsanguination and fluid resuscitation:
experimental validation against a reference technique

5.6 Medical ICU
Kutter AP, Mosing M, Hartnack S, Raszplewicz J, Renggli M, Mauch JY, Hofer CK

The Influence of Acute Pulmonary Hypertension on Cardiac Output Measurements: Calibrated Pulse Contour
Analysis, Transpulmonary and Pulmonary Artery Thermodilution Against a Modified Fick Method in an
Animal Model

Luo JC, Qiu XH, Pan C, Xie JF, Yu T, Liu L, Yang Y, Qiu HB

Increased cardiac index attenuates septic acute kidney injury: a prospective observational study
BMC Anesthesiol 2015; 15: 22


Extravascular Lung Water, B-Type Natriuretic Peptide, and Blood Volume Contraction Enable Diagnosis of
Weaning-Induced Pulmonary Edema
Crit Care Med 2014; 42(8): 1882 - 9


Transpulmonary Thermodilution Enables to Detect Small Short-Term Changes in Extravascular Lung Water
Induced by a Bronchoalveolar Lavage
Crit Care Med 2014; 42(8): 1869-73

Trepte CB, Bachmann K, Stork JH, Friedheim TJ, Hinsch A, Goepfert MS, Mann O, Izbicki JR, Goetz AE, Reuter DA

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

Chew MS, Ihrman L, During J, Bergenzaun L, Ersson A, Unden J, Ryden J, Akerman E, Larsson M

Extravascular lung water index improves the diagnostic accuracy of lung injury in patients with shock
Crit Care 2012; 16(1): R1
Saugel B, Ringmaier S, Holzapfel K, Schuster T, Phillip V, Schmid RM, Huber W
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): 402-10
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Volume assessment in patients with necrotizing pancreatitis: A comparison of intrathoracic blood volume index (ITBI), central venous pressure, and hematocrit, and their correlation to cardiac index and extravascular lung water index
Crit Care Med 2008; 36 (8): 2348-54
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