

Michael R. Pinsky · Laurent Brochard
Göran Hedenstierna · Massimo Antonelli
Editors

Applied Physiology in Intensive Care Medicine 1

Physiological Notes
Technical Notes
Seminal Studies in Intensive Care
Third Edition

 Springer

Contents

1. Physiological Notes

1.1 Pulmonary

1.1.1 Respiratory Mechanics

Intrinsic (or auto-) PEEP during controlled mechanical ventilation	3
LAURENT BROCHARD	

Intrinsic (or auto-) positive end-expiratory pressure during spontaneous or assisted ventilation	7
LAURENT BROCHARD	

Work of breathing	11
BELEN CABELLO, JORDI MANCEBO	

Interpretation of airway pressure waveforms	15
EVANS R. FERNÁNDEZ-PÉREZ, ROLF D. HUBMAYR	

Measurement of respiratory system resistance during mechanical ventilation	17
CLAUDE GUERIN, JEAN-CHRISTOPHE RICHARD	

Understanding wasted/ineffective efforts in mechanically ventilated COPD patients using the Campbell diagram	21
THEODOROS VASSILAKOPOULOS	

Is there an optimal breath pattern to minimize stress and strain during mechanical ventilation?	25
JOSEF X. BRUNNER, MARC WYSOCKI	

1.1.2 Gas Exchange

Dead space	31
UMBERTO LUCANGELO, LLUIS BLANCH	

The multiple inert gas elimination technique (MIGET)	35
PETER D. WAGNER	

Alveolar ventilation and pulmonary blood flow: the \dot{V}_A/\dot{Q} concept	43
ENRICO CALZIA, PETER RADERMACHER	

Mechanisms of hypoxemia	47
ROBERT RODRÍGUEZ-ROISIN, JOSEP ROCA	

Pulse oximetry	51
AMAL JUBRAN	

Effects of body temperature on blood gases	55
ANDREAS BACHER	

Venous oximetry	59
FRANK BLOOS, KONRAD REINHART	

Relation between PaO_2/FiO_2 ratio and FiO_2: a mathematical description	63
JÉRÔME ABOAB, BRUNO LOUIS, BJÖRN JONSON, LAURENT BROCHARD	

Hypoxemia due to increased venous admixture: influence of cardiac output on oxygenation	67
JUKKA TAKALA	

A critique of Stewart's approach: the chemical mechanism of dilutional acidosis	71
DANIEL DOBERER, GEORG-CHRISTIAN FUNK, KARL KIRCHNER, BRUNO SCHNEEWEISS	

1.2 Cardiovascular

Pulmonary vascular resistance: A meaningless variable?	79
ROBERT NAEIJE	

Pulmonary artery occlusion pressure	83
MICHAEL R. PINSKY	

Clinical significance of pulmonary artery occlusion pressure	87
MICHAEL R. PINSKY	

Pulmonary capillary pressure	91
JUKKA TAKALA	

Ventricular interdependence: how does it impact on hemodynamic evaluation in clinical practice?	95
FRANÇOIS JARDIN	
Cyclic changes in arterial pressure during mechanical ventilation	99
FRANÇOIS JARDIN	
Left ventricular rotation: a neglected aspect of the cardiac cycle	103
STEFAN BLOECHLINGER, WILHELM GRANDER, JUERG BRYNER, MARTIN W. DÜNSER	
1.3 Metabolism and Renal Function	
Lactic acidosis	111
DANIEL DE BACKER	
Defining acute renal failure: physiological principles	115
RINALDO BELLOMO, JOHN A. KELLUM, CLAUDIO RONCO	
Hypotension during intermittent hemodialysis: new insights into an old problem	121
FRÉDÉRIQUE SCHORTGEN	
1.4 Cerebral Function	
Intracranial pressure. Part one: Historical overview and basic concepts	127
PETER J. D. ANDREWS, GIUSEPPE CITERIO	
Intracranial pressure. Part two: Clinical applications and technology	131
GIUSEPPE CITERIO, PETER J. D. ANDREWS	
Neuromonitoring in the intensive care unit. Part I. Intracranial pressure and cerebral blood flow monitoring	135
ANUJ BHATIA, ARUN KUMAR GUPTA	
Neuromonitoring in the intensive care unit. Part II. Cerebral oxygenation monitoring and microdialysis	145
ANUJ BHATIA, ARUN KUMAR GUPTA	
The relationship between the intracranial pressure–volume index and cerebral autoregulation	153
A. LAVINIO, F. A. RASULO, E. DE PERI, M. CZOSNYKA, N. LATRONICO	
2. Technical Notes	
2.1 Sub-section Respiratory	
A new automated method versus continuous positive airway pressure method for measuring pressure–volume curves in patients with acute lung injury	159
ENRIQUE PIACENTINI, MARC WYSOCKI, LLUIS BLANCH	
Bedside estimation of recruitable alveolar collapse and hyperdistension by electrical impedance tomography	165
EDUARDO L. V. COSTA, JOÃO BATISTA BORGES, ALEXANDRE MELO, FERNANDO SUAREZ-SIPMANN, CARLOS TOUFEN JR, STEPHAN H. BOHM, MARCELO B. P. AMATO	
Cuff-leak test for the diagnosis of upper airway obstruction in adults: a systematic review and meta-analysis	171
MARIA ELENA OCHOA, MARIA DEL CARMEN MARÍN, FERNANDO FRUTOS-VIVAR, FEDERICO GORDO, JAIME LATOUR-PÉREZ, ENRIQUE CALVO, ANDRES ESTEBAN	
Reproduction of inert gas and oxygenation data: a comparison of the MIGET and a simple model of pulmonary gas exchange	181
STEPHEN E. REES, S. KJÆRGAARD, S. ANDREASSEN, G. HEDENSTIERNA	
Performance of different continuous positive airway pressure helmets equipped with safety valves during failure of fresh gas supply	189
MANUELA MILAN, ALBERTO ZANELLA, STEFANO ISGRÒ, SALUA ABD EL AZIZ EL SAYED DEAB, FEDERICO MAGNI, ANTONIO PESENTI, NICOLÒ PATRONITI	
Validation of Bohr dead space measured by volumetric capnography	195
GERARDO TUSMAN, FERNANDO SUAREZ-SIPMANN, JOÃO B. BORGES, GÖRAN HEDENSTIERNA, STEPHAN H. BOHM	
2.2 Sub-section Hemodynamic	
Lithium dilution cardiac output measurement in the critically ill patient: determination of precision of the technique	201
M. CECCONI, D. DAWSON, R. M. GROUNDS, A. RHODES	

Tracking changes in cardiac output: methodological considerations for the validation of monitoring devices	209	3. Seminal Studies in Intensive Care	
PIERRE SQUARA, MAURIZIO CECCONI, ANDREW RHODES, MERVYN SINGER, JEAN-DANIEL CHICHE		Manipulating afterload for the treatment of acute heart failure. A historical summary	265
		CLAUDE PERRET, JEAN-FRANÇOIS ENRICO	
The influence of the airway driving pressure on pulsed pressure variation as a predictor of fluid responsiveness	217	Nosocomial pneumonia	269
LAURENT MULLER, GUILLAUME LOUART, PHILIPPE-JEAN BOUSQUET, DAMIEN CANDELA, LANA ZORIC, JEAN-EMMANUEL DE LA COUSSAYE, SAMIR JABER, JEAN-YVES LEFRANT		WALDEMAR G. JOHANSON, LISA L. DEVER	
Diagnostic accuracy of passive leg raising for prediction of fluid responsiveness in adults: systematic review and meta-analysis of clinical studies	225	The introduction of positive endexpiratory pressure into mechanical ventilation: a retrospective	277
FABIO CAVALLARO, CLAUDIO SANDRONI, CRISTINA MARANO, GIUSEPPE LA TORRE, ALICE MANNOCCI, CHIARA DE WAURE, GIUSEPPE BELLO, RICCARDO MAVIGLIA, MASSIMO ANTONELLI		KONRAD J. FALKE	
Fluid responsiveness predicted by noninvasive Bioreactance-based passive leg raise test	235	Elastic pressure-volume curves in acute lung injury and acute respiratory distress syndrome	281
BRAHIM BENOMAR, ALEXANDRE OUATTARA, PHILIPPE ESTAGNASIE, ALAIN BRUSSET, PIERRE SQUARA		BJÖRN JONSON	
Comparison of cardiac output and blood volumes in intrathoracic compartments measured by ultrasound dilution and transpulmonary thermodilution methods	243	The concept of “baby lung”	289
GENNADY GALSTYAN, MYCHAYLO BYCHININ, MIKAEL ALEXANYAN, VLADIMIR GORODETSKY		LUCIANO GATTINONI, ANTONIO PESENTI	
In vivo accuracy of two intraparenchymal intracranial pressure monitors	249	The effects of anesthesia and muscle paralysis on the respiratory system	299
THOMAS LESCOT, VINCENT REINA, YANNICK LE MANACH, FILIPPO BOROLI, DORIAN CHAUVET, ANNE-LAURE BOCH, LOUIS PUYBASSET		GÖRAN HEDENSTIERNA, LENNART EDMARK	
Effect of tidal volume, intrathoracic pressure, and cardiac contractility on variations in pulse pressure, stroke volume, and intrathoracic blood volume	255	Diaphragmatic fatigue during sepsis and septic shock	309
JAUME MESQUIDA, HYUNG KOOK KIM, MICHAEL R. PINSKY		SOPHIE LANONE, CAMILLE TAILLÉ, JORGE BOCZKOWSKI, MICHEL AUBIER	
		The use of severity scores in the intensive care unit	317
		JEAN-ROGER LE GALL	
		Oxygen transport—the oxygen delivery controversy	323
		JEAN-LOUIS VINCENT, DANIEL DE BACKER	
		Organ dysfunction during sepsis	331
		SUVEER SINGH, TIMOTHY W. EVANS	
		Ventilator-induced lung injury: from the bench to the bedside	343
		LORRAINE N. TREMBLAY, ARTHUR S. SLUTSKY	
		Remembrance of weaning past: the seminal papers	353
		MARTIN J. TOBIN	
		Interactions between respiration and systemic hemodynamics. Part I: basic concepts	363
		FRANÇOIS FEIHL, ALAIN F. BROCCARD	

Interactions between respiration and systemic hemodynamics. Part II: practical implications in critical care	373	Impact of acute hypercapnia and augmented positive end-expiratory pressure on right ventricle function in severe acute respiratory distress syndrome	407
FRANÇOIS FEIHL, ALAIN F. BROCCARD		ARMAND MEKONTSO DESSAP, CYRIL CHARRON, JÉRÔME DEVAQUET, JÉRÔME ABOAB, FRANÇOIS JARDIN, LAURENT BROCHARD, ANTOINE VIEILLARD-BARON	
Systemic and microcirculatory responses to progressive hemorrhage	381	Goal-directed therapy in high-risk surgical patients: a 15-year follow-up study	417
ARNALDO DUBIN, MARIO OMAR POZO, GONZALO FERRARA, GASTÓN MURIAS, ENRIQUE MARTINS, CARLOS CANULLÁN, HÉCTOR SAUL CANALES, VANINA SIHAM KANOORE EDUL, ELISA ESTENSSORÓ, CAN INCE		ANDREW RHODES, MAURIZIO CECCONI, MARK HAMILTON, JAN POLONIECKI, JUSTIN WOODS, OWEN BOYD, DAVID BENNETT, R. MICHAEL GROUNDS	
Fluid resuscitation influences cardiovascular performance and mortality in a murine model of sepsis	391	Time course of organ failure in patients with septic shock treated with hydrocortisone: results of the Corticus study	423
SERGIO L. ZANOTTI-CAVAZZONI, MASSIMILIANO GUGLIELMI, JOSEPH E. PARRILLO, TRACY WALKER, R. PHILLIP DELLINGER, STEVEN M. HOLLENBERG		R. MORENO, C. L. SPRUNG, D. ANNANE, S. CHEVRET, J. BRIEGEL, D. KEH, M. SINGER, Y. G. WEISS, D. PAYEN, B. H. CUTHBERTSON, J.-L. VINCENT	
Modeling the effect of time-dependent exposure on intensive care unit mortality	399	Index	431
MARTIN WOLKEWITZ, JAN BEYERSMANN, PETRA GASTMEIER, MARTIN SCHUMACHER			

The two previous editions of *Applied Physiology in Intensive Care Medicine* proved extremely successful, and the book has now been revised and split into two volumes to enhance ease of use. This first volume comprises three elements “physiological notes, technical notes, and seminal studies”. The physiological notes concisely and clearly capture the essence of the physiological perspectives underpinning our understanding of disease and response to therapy. The technical notes then succinctly explain some of the basics of “how to” in this technology-centered field of critical care medicine. Finally, a number of seminal studies are provided on diverse topics in intensive care.

Applied Physiology in Intensive Care has been written by some of the most renowned experts in the field and provides an up-to-date compendium of practical bedside knowledge essential to the effective delivery of acute care medicine. It will serve the clinician as an invaluable reference source on key issues regularly confronted in everyday practice.



Critical Care Medicine



► springer.com

Pinsky
Brochard
Hedenstierna
Antonelli
Editors
**Applied Physiology
in Intensive
Care Medicine**
Volume 1
Physiological Notes
Technical Notes
Seminal Studies in
Intensive Care
Third Edition




Michael R. Pinsky · Laurent Brochard
Jordi Mancebo · Massimo Antonelli
Editors

Applied Physiology in Intensive Care Medicine 2

Physiological Reviews and Editorials

Third Edition

 Springer

Contents

1. Physiological Reviews

1.1 Measurement Techniques

Fluid responsiveness in mechanically ventilated patients: a review of indices used in intensive care	3
KARIM BENDJELID, JACQUES-A. ROMAND	

Different techniques to measure intra-abdominal pressure (IAP): time for a critical re-appraisal	13
MANU L. N. G. MALBRAIN	

Tissue capnometry: does the answer lie under the tongue?	29
ALEXANDRE TOLEDO MACIEL, JACQUES CRETEUR, JEAN-LOUIS VINCENT	

Noninvasive monitoring of peripheral perfusion	39
ALEXANDRE LIMA, JAN BAKKER	

Ultrasonographic examination of the venae cavae	51
FRANÇOIS JARDIN, ANTOINE VIEILLARD-BARON	

Passive leg raising	55
XAVIER MONNET, JEAN-LOUIS TEBOUL	

1.2 Physiological Processes

Sleep in the intensive care unit	61
SAIRAM PARTHASARATHY, MARTIN J. TOBIN	

Magnesium in critical illness: metabolism, assessment, and treatment	71
J. LUIS NORONHA, GEORGE M. MATUSCHAK	

Pulmonary endothelium in acute lung injury: from basic science to the critically ill	85
S. E. ORFANOS, I. MAVROMMATI, I. KOROVESI, C. ROUSSOS	

Pulmonary and cardiac sequelae of subarachnoid haemorrhage: time for active management?	99
C. S. A. MACMILLAN, I. S. GRANT, P. J. D. ANDREWS	

Permissive hypercapnia — role in protective lung ventilatory strategies	111
JOHN G. LAFFEY, DONALL O' CROININ, PAUL MCLOUGHLIN, BRIAN P. KAVANAGH	

Right ventricular function and positive pressure ventilation in clinical practice: from hemodynamic subsets to respirator settings	121
FRANÇOIS JARDIN, ANTOINE VIEILLARD-BARON	

Acute right ventricular failure—from pathophysiology to new treatments	131
ALEXANDRE MEBAZAA, PETER KARPATI, ESTELLE RENAUD, LARS ALGOTSSON	

Red blood cell rheology in sepsis	143
M. PIAGNERELLI, K. ZOUAOUI BOUDJELTIA, M. VANHAEVERBEEK, J.-L. VINCENT	

Stress-hyperglycemia, insulin and immunomodulation in sepsis	153
PAUL E. MARIK, MURUGAN RAGHAVAN	

Hypothalamic-pituitary dysfunction in critically ill patients with traumatic and nontraumatic brain injury	163
IOANNA DIMOPOULOU, STYLIANOS TSAGARAKIS	

Matching total body oxygen consumption and delivery: a crucial objective?	173
PIERRE SQUARA	

Normalizing physiological variables in acute illness: five reasons for caution	183
BRIAN P. KAVANAGH, L. JOANNE MEYER	

Interpretation of the echocardiographic pressure gradient across a pulmonary artery band in the setting of a univentricular heart	191
SHANE M. TIBBY, ANDREW DURWARD	

Ventilator-induced diaphragm dysfunction: the clinical relevance of animal models	197
THEODOROS VASSILAKOPOULOS	
Understanding organ dysfunction in hemophagocytic lymphohistiocytosis	207
CAROLINE CRÉPUT, LIONEL GALICIER, SOPHIE BUYSE, ELIE AZOULAY	
What is normal intra-abdominal pressure and how is it affected by positioning, body mass and positive end-expiratory pressure?	219
B. L. DE KEULENAER, J. J. DE WAELE, B. POWELL, M. L. N. G. MALBRAIN	
Determinants of regional ventilation and blood flow in the lung	227
ROBB W. GLENNY	
The endothelium: physiological functions and role in microcirculatory failure during severe sepsis	237
H. AIT-OUFELLA, E. MAURY, S. LEHOUX, B. GUIDET, G. OFFENSTADT	
Vascular hyporesponsiveness to vasopressors in septic shock: from bench to bedside.	251
B. LEVY, S. COLLIN, N. SENNOUN, N. DUCROCQ, A. KIMMOUN, P. ASFAR, P. PEREZ, F. MEZIANI	
Monitoring the microcirculation in the critically ill patient: current methods and future approaches	263
DANIEL DE BACKER, GUSTAVO OSPINA-TASCON, DIAMANTINO SALGADO, RAPHAËL FAVORY, JACQUES CRETEUR, JEAN-LOUIS VINCENT	
The role of vasoactive agents in the resuscitation of microvascular perfusion and tissue oxygenation in critically ill patients	277
E. CHRISTIAAN BOERMA, CAN INCE	
Interpretation of blood pressure signal: physiological bases, clinical relevance, and objectives during shock states	293
J.-F. AUGUSTO, J.-L. TEBOUL, P. RADERMACHER, P. ASFAR	
Deadspace ventilation: a waste of breath!	303
PRATIK SINHA, OLIVER FLOWER, NEIL SONI	

2. Editorials

The role of the right ventricle in determining cardiac output in the critically ill	317
M. R. PINSKY	
Beyond global oxygen supply-demand relations: in search of measures of dysoxia	319
M. R. PINSKY	
Breathing as exercise: The cardiovascular response to weaning from mechanical ventilation	323
MICHAEL R. PINSKY	
Variability of splanchnic blood flow measurements in patients with sepsis – physiology, pathophysiology or measurement errors?	327
S. M. JAKOB, J. TAKALA	
Functional hemodynamic monitoring	331
MICHAEL R. PINSKY	
Non-invasive ventilation in acute exacerbations of chronic obstructive pulmonary disease: a new gold standard?	335
M.W. ELLIOTT	
The adrenergic coin: perfusion and metabolism	339
KARL TRÄGER, PETER RADERMACHER, XAVIER LEVERVE	
Death by parenteral nutrition	343
PAUL E. MARIK, MICHAEL R. PINSKY	
Ventilator-induced lung injury, cytokines, PEEP, and mortality: implications for practice and for clinical trials	347
ARTHUR S. SLUTSKY, YUMIKO IMAI	
Helium in the treatment of respiratory failure: why not a standard?	351
ENRICO CALZIA, PETER RADERMACHER	
Is parenteral nutrition guilty?	355
PETER VARGA, RICHARD GRIFFITHS, RENÉ CHIOLERO, GÉRARD NITENBERG, XAVIER LEVERVE, MAREK PERTKIEWICZ, ERICH ROTH, JAN WERNERMAN, CLAUDE PICHARD, JEAN-CHARLES PREISER	

Using ventilation-induced aortic pressure and flow variation to diagnose preload responsiveness	359	Can one predict fluid responsiveness in spontaneously breathing patients?	385
MICHAEL R. PINSKY		DANIEL DE BACKER, MICHAEL R. PINSKY	
Evaluation of left ventricular performance: an insolvable problem in human beings? The Graal quest	363	The "open lung" compromise	389
ALAIN NITENBERG		JOHN J. MARINI	
Evaluation of fluid responsiveness in ventilated septic patients: back to venous return	367	Acute respiratory failure: back to the roots!	393
PHILIPPE VIGNON		CHRISTIAN MUELLER	
Mask ventilation and cardiogenic pulmonary edema: "another brick in the wall"	371	Is right ventricular function the one that matters in ARDS patients? Definitely yes	397
SANGEETA MEHTA, STEFANO NAVA		ANTOINE VIEILLARD-BARON	
Does high tidal volume generate ALI/ARDS in healthy lungs?	375	Strong ion gap and outcome after cardiac arrest: another nail in the coffin of traditional acid-base quantification	401
CHIARA BONETTO, PIERPAOLO TERRAGNI, V. MARCO RANIERI		PATRICK M. HONORE, OLIVIER JOANNES-BOYAU, WILLEM BOER	
Weaning failure from cardiovascular origin	379	Prone positioning for ARDS: defining the target	405
CHRISTIAN RICHARD, JEAN-LOUIS TEBOUL		JOHN J. MARINI	
The hidden pulmonary dysfunction in acute lung injury	383	Index	409
GÖRAN HEDENSTIERNA			

The two previous editions of *Applied Physiology in Intensive Care Medicine* proved extremely successful, and the book has now been revised and split into two volumes to enhance ease of use. In this second volume some of the most renowned experts in the field offer detailed reviews on measurement techniques and physiological processes of crucial importance in intensive care medicine. Throughout, a key aim is to help overcome the fundamental unevenness in clinicians' understanding of applied physiology, which can lead to suboptimal treatment decisions.

Applied Physiology in Intensive Care has been written by some of the most renowned experts in the field and provides an up-to-date compendium of practical bedside knowledge essential to the effective delivery of acute care medicine. It will serve the clinician as an invaluable reference source on key issues regularly confronted in everyday practice.

Pinsky
Brochard
Mancebo
Antonelli
Editors

**Applied Physiology
in Intensive**

Care Medicine

Volume 2

Physiological Reviews
and Editorials

Third Edition

Critical Care Medicine



► springer.com

