



ERS | practical

Handbook

Invasive Mechanical Ventilation

Editors

Leo Heunks

Marcus J. Schultz



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Table of contents

Contributors	vii
Preface	xiv
Get more from this Practical Handbook	xvii
List of abbreviations	xviii
Conflicts of interest	xix
1. Physiology	
Mechanisms of hypoxaemia and hypercapnia	1
Rebecca F. D’Cruz and Nicholas Hart	
Respiratory mechanics	8
Guilherme Benfatti Olivato, Robert Huhle, Marcelo Gama de Abreu and Ary Serpa Neto	
Effects of invasive ventilation on the lungs	16
Irene Cavalli, Tommaso Tonetti and V. Marco Ranieri	
Effects of invasive ventilation on the respiratory muscles	26
Annemijn H. Jonkman, Zhong-Hua Shi and Leo Heunks	
2. Getting the basics right: artificial airway and ventilator modes	
Artificial airways	33
Christian S. Bruells and Tim Frenzel	
Controlled modes	43
Jakob Wittenstein, Robert Huhle and Marcelo Gama de Abreu	
Partially supported modes	53
Christian Putensen and Stefan Muenster	
Proportional modes	62
Michela Rauseo and Lise Piquilloud	

Automated modes	74
Jean-Michel Arnal and Cenk Kirakli	
3. Getting the basics right: mechanical ventilation in specific diseases	
Invasive ventilation in ARDS	81
Irene Telias, Lieuwe D. Bos and Eddy Fan	
Invasive ventilation in obstructive airway disease	88
Louis-Marie Galerneau, Claude Guérin and Nicolas Terzi	
Invasive ventilation in interstitial lung diseases	95
Sunil Patel, Ricardo Estêvão Gomes and Antonio M. Esquinas	
4. Monitoring the ventilated patient	
Monitoring oxygenation	100
Marco Giani and Giacomo Bellani	
Monitoring ventilation	105
Luis Morales-Quinteros, Lluís Blanch and Antonio Artigas	
Monitoring respiratory mechanics	111
Cong Lu, Nicole Philips and Lu Chen	
Monitoring breathing effort	119
Heder J. de Vries and Leo Heunks	
Electrical impedance tomography	129
Inéz Frerichs, Tobias Becher and Norbert Weiler	
Monitoring lung aeration: lung ultrasound	136
Ezgi Ozyilmaz and Annia Schreiber	
Monitoring respiratory muscles: respiratory muscle ultrasound	147
Pieter R. Tuinman and Nic Tjahjadi	

Monitoring lung pathology: chest radiography and computed tomography	154
Lara Pisani, Giuseppe Francesco Sferrazza Papa and Davide Chiumello	
Monitoring patient-ventilator interaction	159
Candelaria de Haro, Leonardo Sarlabous, José Aquino Esperanza, Rudys Magrans and Lluís Blanch	
5. Supportive therapy and rescue strategies in hypoxaemic failure	
Extracorporeal lung support	171
Christoph Fisser and Thomas Bein	
Prone position in ARDS	177
Hernán Aguirre-Bermeo and Jordi Mancebo	
Recruitment manoeuvres	185
Carmen Sílvia Valente Barbas and Gustavo Faissol Janot de Matos	
Pulmonary vasoactive drugs	195
Luigi Camporota and Francesco Vasques	
6. Inhalation therapy in ventilated patients	
Inhalation therapy in ventilated patients	201
Federico Longhini and Paolo Navalesi	
7. Weaning from mechanical ventilation	
Weaning definition and outcome	207
Laurent Brochard, Michael Sklar and Martin Dres	
Weaning protocols and automatic modes	214
Louise Rose	
Failure to wean and causes for difficult weaning	221
Alexandra Beurton and Martin Dres	

Weaning: a practical approach 227
Rebecca F. D'Cruz, Nicholas Hart and Georgios Kaltsakas

Tracheostomy 235
Elise Morawiec, Bernard Fikkers and Alexandre Demoule

Physiotherapy and speech therapy in ventilated patients 242
Rik Gosselink and Christina Iezzi

8. Technical aspects of the ventilator

Technical aspects of the ventilator 252
Frans de Jongh and Peter Somhorst

Index

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Preface

“读万卷书不如行万里路”
“First read plenty of books, then travel plenty of places”
Confucius, 551–479 BC

Thank you for picking up this *ERS Practical Handbook of Invasive Mechanical Ventilation*. In doing so you are probably interested in artificial ventilation in general, and “invasive ventilation” in particular, but you also appear interested in reading a medical book. The former is not surprising if you are a doctor or nurse treating patients in need of ventilatory support: artificial ventilation is the cornerstone of the treatment of acute respiratory failure. The interesting question is, why would you still read a medical book in 2020? Many people have unrestricted access to hundreds of medical journals online, in addition to a variety of apps, podcasts and online videos. All these “electronic” services provide an endless amount of useful, if not practical information, and such media undoubtedly will become even more important now artificial intelligence and machine learning have entered our profession. New sources of information are a fantastic achievement, which have not only increased, and continue to increase access to information, but have probably also improved patient care, and thus patient outcomes.

However, with so much information at hand one may not see the wood for the trees. Indeed, during our daily rounds or when teaching trainees, we noticed that trainees were very aware of the most recently published RCTs on ventilatory support but frequently lacked a basic knowledge of ventilator modes, patient-ventilator interaction and ways to monitor invasively ventilated patients.

For instance, we are all aware of the RCTs that have shown survival benefit when using a low *versus* a high V_t in patients with ARDS. But does it matter whether a low V_t is delivered in a controlled mode, in a partially supported mode, or maybe in an automated, artificial intelligence-driven mode? Is a low V_t always protective? Does a low V_t , maybe, affect patient-ventilator interactions, respiratory muscle function, or even haemodynamics? To answer these questions, a fundamental understanding of the basics of invasive ventilation is required.

But there are several other topics to be discussed at the bedside. How should we act when hypoxaemia becomes refractory? When should we consider prone positioning and how does prone positioning improve outcome? What are the effects on ventilation/perfusion ratios? Is there still a role for inhalation

therapies, lung recruitment manoeuvres and extracorporeal oxygenation and decarboxylation? What are their indications, and how are they best applied in clinical practice? What are the principles of artificial ventilation in patients with obstructive lung diseases or patients with interstitial lung diseases? This handbook provides concise information that is useful at the bedside for safe ventilation in patients with different lung diseases, written by recognised experts.

A prerequisite for safe invasive ventilation is adequate respiratory monitoring. Clinicians have several techniques available at the bedside, including pulse oximetry, chest radiography and CT, and lung ultrasound, but also more sophisticated techniques, such as electrical impedance tomography and oesophageal pressure measurements. Experts in this field describe the principles of these techniques, possible indications and pitfalls. This will help the clinician to choose the appropriate monitoring technique for invasively ventilated patients under different clinical conditions.

Last but not least, the process of liberating a patient from invasive ventilation, *i.e.* weaning, requires much attention. How can partially supported modes or automated modes help here? And what if a patient fails to wean? When can a tracheostomy be helpful? Especially in awake, spontaneously breathing patients, it could be important to monitor patient-ventilator interactions, respiratory mechanics and breathing efforts. Although many scientific papers have been published about weaning from invasive ventilation, very few provide clinical guidance about how to set the ventilator in a weaning patient. Experts in the field of ventilator weaning provide useful recommendations about how to ventilate patients during the weaning process and a practical approach to the difficult to wean patient.

All the of above is covered in the chapters in this book that all follow a similar approach: providing basic background information, helpful graphics, a summary of the evidence, and finally a list for further reading.

To finish, we would like to express our sincere gratitude to the authors that have contributed to this book – they are the experts and the knowledge-base that drives this book. Selection of authors for this book was by an invitation to the members of Assembly 2 of the European Respiratory Society (ERS), made during the ERS International Congress in Paris, France in 2018. Both early career members and senior members responded enthusiastically and spent their valuable time writing these chapters for you. We would also like to thank the ERS publications office for their support and hard work to complete this ambitious project. And thank you, dear reader, for picking up this handbook. We hope you enjoy reading it and that it helps you to improve your understanding of the basics of invasive ventilation. After reading this book, you will spend more time at the bedside applying what you learned from the

nicely written chapters in this book. Choosing the correct individual settings, the best mode, closely observing how the ventilator and patient interact, and understanding what you actually monitor will certainly further improve your knowledge of invasive mechanical ventilation. To paraphrase Confucius: First read plenty of books, than observe and manage plenty of ventilated patients.

Leo Heunks and Marcus J. Schultz
Chief Editors

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You'll also be able to take the online CME test. This Practical Handbook has been accredited by the European Board for Accreditation in Pneumology (EBAP) for 8 CME credits.

Also available from the ERS

ERS Practical Handbook of Noninvasive Ventilation

Edited by Anita K. Simonds

This handbook provides a concise 'why and how to' guide to NIV from the basics of equipment and patient selection to discharge planning and community care.

Leading clinicians and researchers in the field have been brought together to provide an easy-to-read guide to all aspects of NIV. Topics covered include: equipment, patient selection, adult and paediatric indications, airway clearance and physiotherapy, acute NIV monitoring, NIV in the ICU, long-term NIV, indications for tracheostomy ventilation, symptom palliation, discharge planning and community care, and setting up an NIV service.

List of abbreviations

AHI	Apnoea-hypopnoea index
AIDS	Acquired immunodeficiency syndrome
ALS	Amyotrophic lateral sclerosis
ARDS	Acute respiratory distress syndrome
ARF	Acute respiratory failure
ASB	Assisted spontaneous breathing
ASV	Adaptive servo ventilation
ASSPCV	Assisted pressure-controlled ventilation
AVAPS	Average volume-assured pressure support
BMI	Body mass index
CF	Cystic fibrosis
COPD	Chronic obstructive pulmonary disease
CPAP	Continuous positive airway pressure
ECG	Electrocardiogram
EPAP	Expiratory positive airway pressure
FEV₁	Forced expiratory volume in 1 s
F_{IO₂}	Inspiratory oxygen fraction
FVC	Forced vital capacity
HIV	Human immunodeficiency virus
ICU	Intensive care unit
IPAP	Inspiratory positive airway pressure
IPPV	Intermittent positive pressure ventilation
IVAPS	Intelligent volume-assured pressure support
NIV	Noninvasive ventilation
NPV	Negative pressure ventilation
OHS	Obesity hypoventilation syndrome
OSA(S)	Obstructive sleep apnoea (syndrome)
P_{aCO₂}	Arterial carbon dioxide tension
P_{aO₂}	Arterial oxygen tension
PAV	Proportional assist ventilation
PCV	Pressure-controlled ventilation
PEEP	Positive end-expiratory pressure
PSV	Pressure support ventilation
P_{tcCO₂}	Transcutaneous carbon dioxide tension
S_{aO₂}	Arterial oxygen saturation
RCT	Randomised controlled trial
SpO₂	Arterial oxygen saturation measured by pulse oximetry
TB	Tuberculosis
TLC	Total lung capacity
VCV	Volume-controlled ventilation
V_t	Tidal volume

Conflicts of interest

Chief Editors

Leo Heunks: reports personal fees from Maquet Critical Care, Sweden (travel and speaking fees), and grants from Orion Pharma, Finland and Ventfree, USA, outside the submitted work.

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