

Artificial Ventilation

A Basic Clinical Guide

David J. Baker

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Preface

The support of breathing by artificial ventilation has been described for several thousands of years but a systematic approach to the subject has only developed in recent times. Mechanical artificial ventilation is now a standard part of medical practice in hospital operating theatres and intensive care units (ICU) as well as in emergencies where normal breathing has failed and in the transport of ventilator – dependent patients both within the hospital and between units, sometimes over a range of several thousand miles. This development has not been straightforward. Normal breathing depends on drawing in air to the lungs by creating a partial vacuum inside the chest cavity. From the seventeenth century onwards artificial ventilation was developed which was the exact reverse of this process with air being forced into the lungs by bellows devices. This was the first mechanical attempt at what is now known as intermittent positive pressure ventilation. During the nineteenth century this approach fell into disrepute and methods of negative pressure artificial ventilation were developed which sought to imitate natural breathing. This led to the development of the first mechanical cabinet ventilator (or ‘iron lung’) and several methods of first aid artificial ventilation by manipulation of the arms. Negative pressure artificial ventilation was, in turn replaced by intermittent positive pressure ventilation in the middle of the twentieth century with ventilation by bag valve devices and early mechanical ventilation in the ICU from the 1950s onwards. Since that time ventilation of the lungs has become an integral part of both hospital practice where disease or injury causes respiratory failure and in emergency medical practice, including cardiopulmonary resuscitation. Although positive pressure artificial ventilation remains common to both prehospital and hospital practice the means of delivering it in these two settings have become widely separated. The increasing sophistication of computer – controlled ICU ventilators has made their operation very much the work of specialists, both medical and nursing and, in the United States, respiratory therapists. The complexity of the ventilators has been driven by the requirements of ICU physicians and respiratory therapists who increasingly require a form of ventilatory support which matches closely normal physiological respiration and is linked to the patient’s own respiratory efforts. Outside the ICU however, many non – specialist medical, paramedical and nursing personnel are

increasingly expected to provide IPPV in emergency settings both in and out of the hospital using more basic portable equipment. This also includes all responders providing ventilation as part of cardiopulmonary resuscitation.

In the emergency setting emergency ventilation has been provided for over 50 years by the use of hand - operated bag – valve devices. The development of portable gas – powered ventilators, starting in the 1970s allowed automatic mechanical ventilation in the emergency setting where large and complex ICU ventilators cannot be used. But portable ventilators too have become complex and are often poorly – understood by many emergency responders who prefer using manual ventilation with bag – valve devices. Recently, the safety and effectiveness of these devices has been brought into question and has raised the profile of the provision of training in artificial ventilation in emergency, which for many years has been rather neglected compared with other aspects of life support.

In addition to emergency ventilation of individual patients, mass artificial ventilation may be required for casualties of trauma both physical, following earthquakes and toxic from chemical agent releases, with the use of stockpiled simple ventilators used in non – ICU hospital high dependency units. Equally, mass ventilation may be required for victims of epidemics as the SARS and Ebola outbreaks have demonstrated in recent years. Even in developed countries, the hospital ventilation capabilities may rapidly be overwhelmed and casualties may have to be ventilated with stockpiled portable ventilators by medical and nursing personnel who have little experience in this area. There has been increasing interest among ventilation professionals in the type of ventilator that should be stockpiled in such situations and the training that should be provided for the users.

There is an evident need for improved training and understanding of the principles and practice of artificial ventilation among non – ventilation specialists. The past three decades have seen the publication of a number of excellent and detailed texts on mechanical ventilation but these have largely been targeted at the hospital specialist and increasingly concern many of the complex modes of ventilation used in the ICU. Conversely, there are few single texts which deal with the basics of airway and ventilation management for those working in prehospital and emergency medicine. This book seeks to fill this gap by providing a basic clinical guide to the principles and practice of artificial ventilation, both manual and mechanical. It covers the development of artificial ventilation through the ages and the essential anatomy and physiology behind it. Non – mechanical methods of ventilation, re – discovered with the development of cardiopulmonary resuscitation in the middle of the last century are considered together with a discussion of the use and limitations of manual ventilation devices. Mechanical ventilation is approached essentially from the standpoint of portable pneumatic ventilators which have become widely used in situations where non – specialists are involved. These devices were also used in the transport of ventilator – dependent patients but have been replaced by more complex electronically – controlled ventilators in recent years. There is now an increasingly wide range of portable ventilators available on the market which makes the decision of which ventilator to buy and use more difficult. Several good comparison studies have been published and these are discussed to give the reader an idea of

what is available. The use of portable ventilators in emergency and transport ventilation is considered together with special situations such as the resuscitation and ventilation of neonates and infants, where non – specialists may find themselves having to respond in the absence of specialist care. Ventilation in difficult settings, where equipment and support services may be limited is also considered together with the important topic of the provision of mass ventilation for disaster and epidemics.

The literature available about artificial ventilation is very extensive and in keeping with the simple approach adopted in this text detailed referencing has been avoided. Instead, each chapter contains suggestions for further reading in the form of texts and key articles and reviews which are likely to be of interest to the non – specialist. Where necessary, important primary sources have also been cited, as well as the latest guidelines on ventilation for basic and advanced life support, published in 2015 by the International Liaison Committee for Resuscitation. These are listed as suggestions for further reading at the end of each chapter.

It would be impossible within the scope of this text to cover all the many mechanical ventilators for emergency and transport ventilation that are currently on the market so I have used a selection of representative devices to illustrate the types of ventilator currently available. Comparative details of a number of portable ventilators are given in two appendices, which is designed to help readers choose which ventilator will be suitable for their requirements. In any book of this size there will inevitably be omissions but the interested reader who may require more detailed information is referred to more detailed works which are readily available and are listed in the suggestions for further reading.

I would like to thank the various authors and publishers who have given permission for reproduction of many of the illustrations in the book. I am also very grateful to the Research and Development section of Pneupac Ventilation, (Smiths Medical International Luton, UK) with whom I have worked for many years and who have provided much help with illustrations and technical data. I would also like to acknowledge the support I have received from my editor, Liz Pope at Springer Verlag without whose help and encouragement this publication would not have been possible. Finally, my thanks go to my wife and anaesthetic colleague Dr Marian Barry for her support and many helpful suggestions.

I hope that this basic guide will be of some help to all those in the medical, paramedical and nursing personnel who are involved in providing artificial ventilation and to whom it is dedicated.

Paris, France

David J. Baker

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