INTENSIVE AND REHABILITATIVE RESPIRATORY CARE

THOMAS L. PETTY

A Practical Approach to the Management of Acute and Chronic Respiratory Failure

Respiratory Care

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Preface

Acute respiratory failure is a common medical emergency encountered by internists, surgeons, anesthesiologists, pediatricians, general practitioners, neurologists, and, in fact, any physician engaged in the practice of medicine today. It occurs when the respiratory apparatus, i.e., lungs and circulation, fails to provide adequate tissue oxygenation and carbon dioxide removal. Thus, respiratory failure may take place in many clinical situations, including chronic lung disease, acute neurological emergencies, poisonings, surgical states, and a variety of other less common but equally compelling clinical problems.

The proper management of patients with acute respiratory failure involves identification, respiratory support, management of the underlying precipitating cause, and prevention or control of complications. The principles of management are simple, but the details of care for each individual patient are more complex and must be adapted to each clinical situation.

The development of an organized team-approach for management of patients with acute respiratory failure has been a major advance of today's medicine and has provided the arena for systematic physiologically oriented care. The disciplines of internal medicine, surgery, anesthesiology, nursing care, inhalation therapy, and physical medicine and rehabilitation all come to bear on problems presented by each individual case.

In spite of recent advances in our understanding of the value of controlled oxygen therapy and the availability of a variety of new ventilators, humidifiers, and nebulizers, many controversies concerning the best means of supporting ventilation and providing adequate oxygenation as well as debate on other methods of care remain. In this book we do not intend to review all of the controversial material in the current literature; we will cite throughout the text only the necessary key references.

This book is based upon seven years' experience in a respiratory care unit for adults in a general medical and surgical hospital. We will primarily refer to our own experience and results, recognizing that excellent results have been reported from other respiratory care units—both from those using techniques similar to ours and those employing different methods. Because of their special nature, we will not deal with the respiratory problems arising in infancy and early childhood.

The major aim of this book is to show how respiratory failure may be efficiently managed in general hospitals and how practical care can be applied at the bedside. A further aim is to stress the rehabilitation potential of patients who recover and to define and describe modern methods of effective extended care directed toward the rehabilitation of patients with moderate or severe respiratory insufficiency.

Two chest physicians, a surgeon, a clinical physiologist, a nurse-inhalation therapist, a public health nurse, and a physical therapist are the authors of this text. Therefore, various points are emphasized in the individual chapters. However, since the authors are all members of the respiratory care team, a cohesive message concerning systematic respiratory care should be evident.

Each chapter is intended to be a fairly independent essay and thus the reader can select an individual chapter for its own message.

The book is intended to be a primer for practitioners, house officers, and all students interested in today's problems in respiratory care including our esteemed workers in the allied health professions. All of these individuals form the care team that, today, encounters increasing numbers of patients with acute and chronic respiratory failure who seek care in our nation's hospitals.

We dedicate this book to all those who have assisted in the organization and development of our respiratory care unit and to our patients. Their contributions, work, and creativeness have been instrumental in the establishment of the methods of care which are the subject of this offering.

Denver, Colorado THOMAS L. PETTY

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Mrs. Martha Melton, Mrs. Patty Way, Mrs. Mary Ellen Klein, Mrs. Martha Conway, and Miss Sharon Forsberg

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F. Statisticians:
Mr. Myron Miller and Mr. Alan Suzuki

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Section A

ACUTE RESPIRATORY FAILURE— METHODS OF CARE

This section deals with the definition, manifestations, and identification of acute respiratory failure and the basic methods of care that are applied in the management of all clinical conditions in which acute respiratory failure occurs.

I

ACUTE RESPIRATORY FAILURE

By Thomas L. Petty, M.D.

DEFINITION

Acute respiratory failure occurs in many clinical situations and constitutes a medical emergency requiring prompt and exacting diagnosis and meticulous management. It may be simply defined as the sudden inability of the respiratory apparatus and heart to maintain adequate arterial oxygenation and adequate carbon dioxide elimination. In the final sense, acute respiratory failure is present when tissue oxygen transport and carbon dioxide excretion are impaired; but because of the difficulties of estimating tissue gas tensions, arterial blood gas analysis is utilized to determine the presence and severity of acute respiratory failure. Arbitrarily, acute respiratory failure is defined as the sudden development of an arterial Po_2 of less than 50 mm Hg with or without CO_2 retention. An acute elevation of carbon dioxide tension to more than 50 mm Hg is called acute ventilatory failure. The separation of hypoxemia from hypercapnia or so-called ventilatory failure has important therapeutic implications.

MANIFESTATIONS

Acute respiratory failure has become a frequently recognized clinical syndrome that can be encountered by physicians in the practice of any medical specialty, particularly in that of internal medicine (e.g. emphysema due to chronic airway obstruction, chronic bronchitis, and asthma); it can be associated with postoperative surgical states, trauma, neurological emergencies, and accidental or self-induced poisonings. Table 1-1 lists the common disease states with which it may occur; the table is organized according to the basic pathophysiological process involved.

TABLE 1-1. Disease States Leading to Respiratory Failure

I. Impaired ventilation
   - A. Chronic airway obstruction
     Emphysema, chronic bronchitis, chronic asthma
   - B. Restrictive defects
     1. Decreased lung expansion
        Interstitial fibrosis, pleural effusion, pneumothorax, fibrothorax
     2. Limited thorax expansion
        Kyphoscoliosis, multiple rib fractures, thoracic surgery, spinal arthritis
     3. Decreased diaphragmatic movement
        Abdominal surgery, ascites, peritonitis, severe obesity
   - C. Neuromuscular defects
     Guillain-Barré syndrome, multiple sclerosis, myasthenia gravis, botulism, tetanus, brain or spinal injuries, drugs or toxic agents (e.g., curare, acetylcholinesterase inhibitors, polymyxin B + E, kanamycin, streptomycin, neomycin), polio
   - D. Respiratory center damage or depression
     Narcotics, barbiturates, tranquilizers, anesthetics, cerebral infarction or trauma, *uncontrolled high-flow oxygen therapy*

II. Impaired diffusion and gas exchange
   - A. Pulmonary fibrosis
     Sarcoidosis, Hamman-Rich syndrome, pneumonoconiosis
   - B. Pulmonary edema
     1. Cardiogenic
     2. Noncardiogenic
   - C. Obliterative pulmonary vascular disease
     Thromboembolism with blood, fat, bone marrow, or amniotic fluid
   - D. Anatomic loss of functioning lung tissue
     Pneumonectomy, tumor

III. Ventilation-perfusion abnormalities and venous admixture
   Emphysema, chronic bronchitis, bronchiolitis, atelectasis, pneumonia, thromboembolism, postperfusion syndrome, and respiratory distress syndromes

A synopsis of the physiological basis for the development of respiratory failure, including problems of ventilation and abnormalities of gas exchange (hypoxemia and hypercapnia), is given in Appendix A.

Various acute pulmonary insults are often *precipitating factors* in the development of acute respiratory failure, particularly when associated with chronic airway obstruction. These include pneumonia (Chapter 13), acute bronchitis, bronchiolitis (Chapter 10), acute bronchial asthma (Chapter 10), and thromboembolism. The acute problems may also precipitate respiratory failure in patients with other chronic pulmonary conditions including restricted ventilation due to pulmonary fibrosis (Chapter 8). It is unusual for pneumothorax (unless accompanied by tension), small pleural effusions, and problems of impaired diaphragmatic excursion alone to cause respiratory failure in the absence of significant underlying lung disease, but these conditions may contribute to the development of acute failure when pulmonary reserve is impaired.

The clinical manifestations of acute respiratory failure are primarily those of the blood gas abnormalities involved. The major clinical signs are listed in Table 1-2. It is clear that these signs do

TABLE 1-2. Clinical Manifestations of Acute Respiratory Failure

Manifestations of underlying disease plus:

1. Restlessness
2. Confusion
3. Tachycardia
4. Diaphoresis
5. Headache
6. Central cyanosis
7. Hypotension
8. Tremors — asterixis
9. Poor chest expansion
10. Depressed respiration
11. Miosis, papilledema
12. Unconsciousness

not necessarily direct one's attention to abnormalities of respiration. Hypoxemia and hypercapnia produce the signs of altered central nervous system[1-1 to 1-5] and impaired circulatory function. This is the main reason why respiratory failure may be misdiagnosed. The most common misdiagnoses are (1) central nervous system catastrophe such as cerebral vascular accident, (2) congestive heart failure, and (3) pneumonia. Remember that one of the most common causes of impaired consciousness is acute respiratory failure.

The clinical signs observed at the bedside of patients suffering from acute respiratory failure will be those of the underlying disease as well as the superimposed signs of hypoxemia and/or hypercapnia. It is our experience that restlessness, headache, confusion, and tachycardia are the four most common signs encountered. It should be stressed that although the clinical features of acute respiratory fail-

ure may be obvious or dramatic at times (as in unconsciousness due to drug ingestion, severe chest trauma, and status asthmaticus, or severe pneumonia), many patients, particularly those with chronic airway obstruction, become ill in so gradual and subtle a fashion that the attending physician, in making his rounds, may fail to spend time at their bedside lest he interfere with their "sleep." In some instances a sedative may be offered for bedtime restlessness.

DIAGNOSIS

Acute respiratory failure must be suspected by alert clinicians and nurses who are aware of the clinical states in which respiratory failure is likely to occur. The diagnosis must be confirmed through laboratory study. Acute respiratory failure is best identified by means of arterial puncture and immediate analysis of a blood sample to determine the pH, Po_2, oxygen saturation, and Pco_2).[1-6] The safety and simplicity of arterial puncture have been established.[1-7] It is impossible to estimate the degree of hypoxemia by clinical signs alone, and cyanosis is a notoriously inadequate guide to determination of the degree of hypoxemia.[1-8]

Figure 1-1 demonstrates the simple equipment needed for an arterial puncture (arterial stick)—a standard 10-cc glass syringe, disposable #20 needle, and dilute heparin (1000 units/cc).

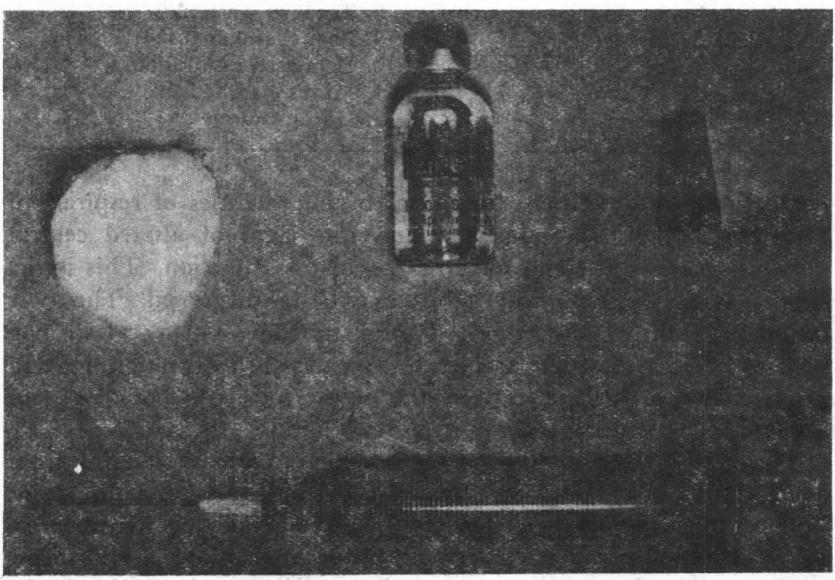

Figure 1-1. Equipment for arterial puncture: a 10-cc glass syringe, a disposable #20 needle, a rubber stopper, dilute heparin, and a cotton sponge.

Figure 1-2. Technique of arterial puncture. Acute-angle insertion into brachial or radial artery. On withdrawal of syringe, pressure should be applied for five minutes. The needle is plunged into the stopper and the anaerobic sample is placed in an ice bath.

The syringe is prepared by drawing sufficient heparin into it to wet the plunger and to fill the dead space of the syringe and the needle. The excess heparin is expelled with the syringe in the upright position. A palpable artery (radial or brachial) is selected. After skin preparation the needle is directed into the artery as shown in Figure 1-2. Usually the initial thrust will bring a pulsating flow of blood into the syringe. It is not necessary to draw outward with the plunger; the spontaneous pulsating flow will be proof of entry into the artery. If the needle fails to enter the artery, simple redirection will usually result in its entry. Occasionally the artery is pierced. When this happens, blood will flow when the needle is withdrawn slightly. After the blood sample has been obtained, the needle is plunged into a rubber stopper. The needle and syringe are then placed in a beaker of ice and taken to the blood gas laboratory for immediate analysis.

This technique of arterial puncture has proven entirely satisfactory and exceedingly safe with no identifiable complications in a large number of individuals followed for months after repeated arterial punctures.[1-7] The ease and relatively painless nature of the procedure make anesthesia and the use of indwelling needles and catheters unnecessary. Following these simple instructions, a clini-

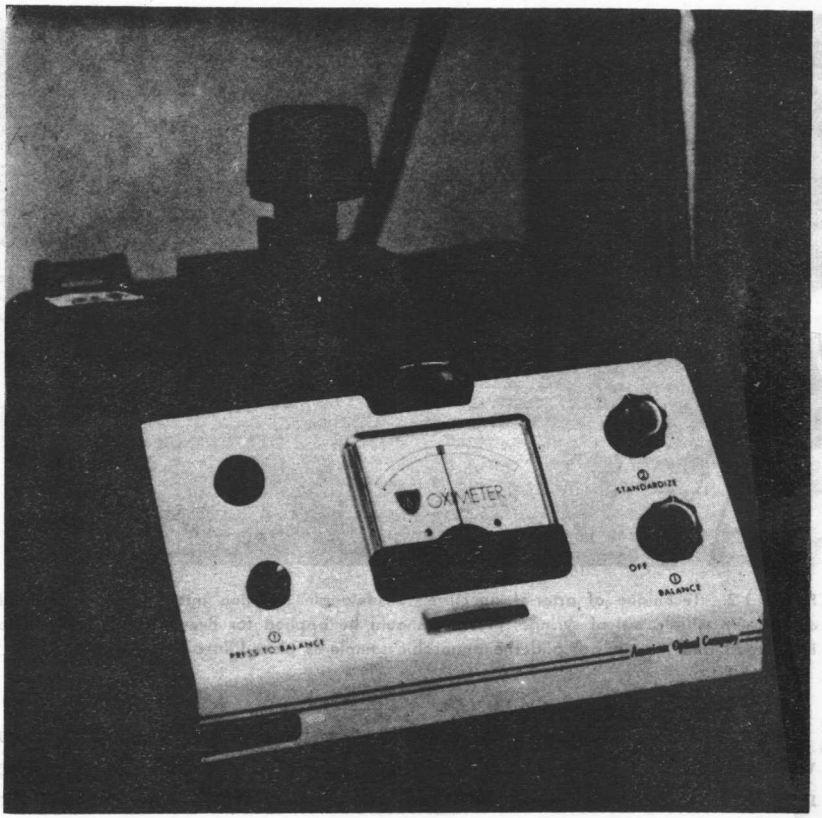

Figure 1-3. Simple dual-beam oximeter for estimation of oxygen saturation.

cian with no special background can learn to perform arterial punctures in a matter of two or three minutes.

Modern oximeters, electrodes, and tonometers have revolutionized blood gas analysis as well as pH determinations.[1-9, 1-10] They have made the use of venous blood for pH and carbon dioxide studies[1-11] obsolete and have replaced indirect methods such as rebreathing techniques.[1-12] With the ease of arterial puncture, the use of arterialized blood from the ear lobe or arterialized venous blood no longer is necessary.[1-13]

Figure 1-3 shows a simple dual-beam oximeter* that is exceedingly accurate in measuring oxygen saturation in the important clinical range of 65 to 95% saturation. Although the device is somewhat inaccurate for measurement of saturation below and above this range, it provides sufficient guidance for the proper administration of oxygen to a patient in acute respiratory failure (Chapter 3).

* American Optical Company, Bedford, Massachusetts.