CRITICAL CARE NURSING

A Physiologic Approach

LINDA ABELS

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LINDA ABELS, R.N., M.S.N.

Adjunct Assistant Professor, School of Nursing,
Indiana University, Indianapolis, Indiana

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Contributors

ANN BELCHER, R.N., M.N.
Assistant Professor, School of Nursing, Indiana University,
Indianapolis, Indiana

JOANN BROOKS-BRUNN, R.N., M.S.N., CCRN
Department of Medical Research, Methodist Hospital,
Indianapolis, Indiana

DEBRA GREENSPAN, R.N., M.S.N.
Clinical Nurse Specialist, Critical Care Units, Touro Infirmary,
New Orleans, Louisiana

ROSEMARY HUME, R.N., M.S.N.
Manager, Human Resource Development,
St. Vincent's Hospital and Health Care Center, Indianapolis, Indiana

MARY ROPKA, R.N., M.S.
Formerly Instructor of Nursing, School of Nursing,
University of Virginia, Charlottesville, Virginia

BARBARA RUSSO, R.N., M.S.N.
Director of Surgical Nursing and Former Coordinator of Critical Care Units,
St. Vincent's Hospital, Indianapolis, Indiana

JAMES SZWED, M.D.
Community Hospital of Indianapolis,
Indianapolis, Indiana

CHERYLL WODNIAK, R.N., M.S.N.
Indiana University, Indianapolis, Indiana

To my husband, Jon,
who has been supportive throughout my professional career;

To my children, Michelle, Benji, Matthew, and Bethie,
who patiently put up with a part-time mother on many occasions;

To my mother and father,
who gave me the courage to tackle the unattainable.

Preface

This comprehensive text utilizes a physiologic approach to review multisystem problems commonly seen in critical care. It serves as a reference for the critical care practitioner and other members of the acute-care health team. The text will also be of value in baccalaureate and graduate nursing programs, as well as in critical care orientation and continuing education courses.

The book is comprised of eight major units: Psychophysiology, Circulation, Respiration, the Nervous System, Fluid and Electrolytes, Alimentation, Coagulation, and Thermoregulation.

Each unit is organized systematically and includes a description of the following:

Developmental anatomy (embryology)
Physiologic review
Complete physical assessment
Synopsis of pathophysiology
Summary of current therapeutic modalities

The discussion of *developmental anatomy* is limited to information that will facilitate an understanding of the beginnings of life and the changes that occur during development. Such knowledge is essential to recognize the relationship between body structure and function.

The *physiologic review* is a study of mammalian functional systems. It describes anatomic, physiologic, and biochemical principles that are integral to the regulation of body activities. Throughout the text, emphasis has been placed on those homeostatic mechanisms essential to the functional operation of each system. An exception is Unit 4, in which the nervous system is approached regionally.

Physical assessment is also described systematically. It consists of pertinent historical, physical, and laboratory data. Particular attention is directed to those concepts most applicable to critical care.

A *pathophysiologic analysis* is made of each symptom presented in the history. A concerted effort has been made to describe symptomatic rather than specific disease pathology.

In regard to the *therapeutic modalities* presented, both independent and dependent interventions are reviewed. Treatment protocols include pharmacologic, nutritional, and rehabilitative regimens. Current research is cited where applicable.

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been completed without my babysitter, Carolyn Robertson, who has been loyal and reliable in rain, sleet, or snow, and without my typist, Joyce Lovelady, who typed, retyped, and retyped again and became as good a medical secretary as a legal secretary.

Linda Abels

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Contents

I Psychophysiology

DEBRA GREENSPAN

The evolution of critical care units has occurred rapidly over the past 29 years in response to the dramatic increase in available medical technology and subsequent role change among nurses. These factors have resulted in constantly improving critical patient care for urban and rural people regardless of socioeconomic conditions.

Florence Nightingale recognized that the critically ill patient needed to have more hours of direct nursing intervention. She recommended that patients be assigned beds according to the severity of their illness, with the most ill patients located closest to the nursing station. This method of bed allocation persisted for nearly 85 years with rare exception. In the ward environment, nurses and physicians experienced gross limitations in their ability to provide critically ill patients with lifesaving emergency measures, including readily available oxygen, suction, treatment room facilities, and specialized physician and nursing staff care. In 1923 a few farsighted thinkers at Johns Hopkins University Hospital realized the inadequacies of this system and developed a three-bed special care unit for the neurosurgical patient.

This unit was designed to provide round-the-clock qualified patient care using house staff and "specially trained" nurses. It must be realized that at this time in history, the role of the nurse was extremely limited, which can be attributed to the role of women in American and European societies of that era. Women were to be protected from the horrors of death and destruction. They were perceived as feeble-minded, nymphlike beings incapable of handling the challenge of providing rational and scientifically based patient care to the critically ill. Consequently, the role of the specially trained nurse working in a special care area did not flourish until the onset of World War II.

Historically, war has brought technologic advances to civilization. World War II was no exception. Modern medicine boomed, rising to meet the challenge of saving war casualties wounded no longer by swords but by technologically advanced explosive weaponry. There was a new demand to refine surgical techniques and to develop anesthetics (needed for longer and more complicated surgical procedures) and antiinfective agents. Medical practitioners soon realized that they were too busy to provide bedside patient care and medical-surgical interventions simultaneously. Immediate postoperative patients required intensive monitoring and observation for at least 24 hours. Here was nursing's opportunity to demonstrate the valuable and necessary role of the specially trained nurse: a nurse who used her eyes, ears, and hands, as well as a highly trained intellect, to provide scientifically based nursing care to the recovering surgical patient. This need to care for postsurgical patients brought forth the concept of a recovery room—a special care unit designed to

Table 1-1. Potential stressors affecting the human organism

Intrapersonal	Body image
	Environment
	Control/power
	Awareness
	Perception/feelings
Interpersonal	Interactional patterns
	Culture
	Socioeconomic patterns
Biologic	Physical disruption of body processes
	Pain
	Decreased mental functioning (such as hypoperfusion)

provide immediate postoperative care, using the latest technology and a well-educated nursing staff. A recovery room made it unnecessary for operating rooms to hold unstable patients, which had been the practice in years past, and made maximum use of available medical, nursing, and auxiliary personnel in short supply.

With the 1950s came new bridges to be crossed by medicine and nursing. Poliomyelitis had reached worldwide epidemic proportions, with thousands of adults and children requiring respiratory-assist devices and intensive nursing care. Concurrently, cardiothoracic surgery had entered a new era, with refinement of intraoperative membrane oxygenation techniques. Children and adults with acquired and congenital heart defects, often living in faraway countries, were seizing the opportunity to live a more normal life by traveling to medical centers that performed the surgeries they needed. Therefore the need for critical care units became obvious in the medical center environment during the early 1950s. Out of this need arose the concepts of intensive and progressive patient care units as we know them today.

Oddly enough, however, it was the community hospital that became the pioneer in designing and implementing special care facilities. In the autumn of 1953 Manchester Memorial Hospital in Manchester, Connecticut opened a four-bed progressive care unit. This was followed by the establishment of an eight-bed critical care unit at North Carolina Memorial Hospital, in Chapel Hill, North Carolina, in January of 1954 and a six-bed critical care unit at Chestnut Hill Hospital in Philadelphia in May, 1954. By February of 1957 there were 20 hospitals in the United States with critical care units, and by May, 1958, there were nearly 150 such units. The concept of intensive care units with specially trained nurses and physicians had come to fruition.

During the 1970s, the term *ICU,* or *intensive care unit,* was gradually replaced with the term *critical care unit,* an umbrella phrase that includes all types of special care units, not just the postsurgical ICU. By 1979, virtually all hospitals had at least one critical care unit.

The challenge of the 1960s and 1970s was represented by an increasing degree of specialization within the medical community. With the accelerated development of new technologies, it was soon necessary to subspecialize ICUs; cardiovascular, renal, coronary, and respiratory ICUs were therefore created, matching nursing expertise with patient needs.

Beginning in the early 1970s, however, nurses became acutely aware that the recovery room design for critical care units was not conducive to the psychologic well-being of patients, their families, or staff members. The recovery room design allocated bedspace in an open ward environment, providing a small number of nurses with a great deal of visibility and ready access to patients. This concept did not consider the impact on patients of noise, lack of privacy, limited personal space, observing other patients during emergency situations, and other environmental stressors on psychologic health. In addition, the role that psychologic health plays in promoting the physical recovery of the patient was not considered. Concomitantly, the effect of this environment on critical care unit staff was not recognized. Indeed, nurses had now been given an opportunity to use their intellect and assessment skills in providing special care to the critically ill, but what would be the cost? Research now points to factors such as noise, high nurse/patient ratios, lack of personal space (such as break areas), and chronic patients or patients who have extended hospitalizations in critical care units as factors that promote "burnout"—the end result of prolonged stress without adequate coping reserves.

An increasing number of institutions have recognized this problem and have designed their new critical care units with private or semiprivate rooms, each with an outside window and other features of normalcy such as clocks, private or semiprivate bathrooms, and wall calendars. This environment appears to foster a higher level of patient and staff morale by limiting the impact of the previously mentioned stress-producing factors.

In a short 30 years, the critical care unit has gone from taking its first "baby steps" to running a multibillion dollar race between technology and disease. There have been many transformations in the environmental design of the critical care unit, as well as in nurse-patient and nurse-physician relationships, that bring form to the concept of the critical care unit. Prolonged patient hospitalizations have been shown to have a profound effect on nurses and on the depth and intensity of their relationships with patients and family members. The challenge that confronts the critical care nurse of the 1980s does not require monetary investments or budget juggling in these troubled economic times; it does require a personal investment in patients, their families, and fellow staff members. The critical care nurse of the '80s must begin to look beyond the patient's infected abdominal wound or acute myocardial infarction and attempt to examine the longstanding conflicts, character traits, and social factors of patients and families.

Within the critical care environment, a dynamic relationship exists among the patient, family, and health care team. Each system is composed of three subsystems: (1) intrapersonal (feelings), (2) interpersonal (communication), and (3) biologic (Table 1-1). Each system has its own sphere of influence with an inherent capacity to affect and be affected by other systems. Within the critical care unit, the patient *(A)*, family *(B)*, and health care team *(C)* function as three interdependent systems (Fig. 1-1).

This relationship can be affected by stress-producing factors within the environment, as well as by intrapersonal, interpersonal, and biologic factors. Unchecked, these factors can and do significantly alter normal physiologic processes. Environmental stressors are easier to identify and augment than intrapersonal and interpersonal stressors. Therefore the remainder of this chapter will concentrate on using the nursing process to support the mental health of critically ill patients and their families without depleting the coping reserves of the nurse.

PSYCHOPHYSIOLOGY

Stress theory: a biopsychosocial perspective

Humans have always been very curious about determining cause and effect relationships. However, the connection between the mind and the body has remained somewhat elusive in spite of enormous research efforts over the past 60 years. From experience, we all know this body-mind connection is real. When we perceive the feeling of fear or anger, our palms

Fig. 1-1. This model demonstrates the interrelatedness of the systems found in the critical care environment: the patient *(A)*, the family *(B)*, and the health care team *(C)*.

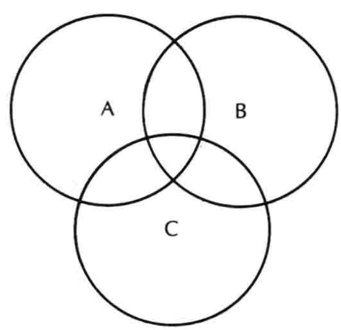

Table 1-2. Manifestations of stress

Affective	Motor-behavioral	Cognitive	Physiologic
Anxious	Agitation	Decreased attention	Increased heart rate and increased blood pressure
Depressed	Rapid movements	Selective inattention	Increased respiratory rate
Fearful	Crying	Joking	Cool extremities (peripheral vasoconstriction)
Joyful	Wringing hands	Altered judgment	Pupil dilation
Angry	Lip smacking	Delusions	Sweaty palms

may begin to sweat and we may have heart palpitations. At times, the physical reaction may precede our conscious awareness of the feeling.

Selye[55] defines stress as a specific syndrome that consists of all the nonspecifically induced changes within a biologic system. This consistent physiologic response is noted to produce both short- and long-term changes in body functions. Enhanced sympathetic tone and adrenal stimulation mark the activation of the body's defenses and are detectable very early in the stress response. With prolonged stress, long-term changes such as shrinkages of lymphatic organs, gastrointestinal ulcers, and loss of body weight may be seen.

Lazarus' theory of stress[43] augments Selye's concepts by justifying a mental appraisal of a stimulus. Lazarus defines stress as anything that is cognitively appraised to be threatening to the body or its ego structure; this may be merely the anticipation of a future confrontation with harm. The potency of the threat is relative to its imminence and the availability of adequate coping resources. The manifestations of stress, often called stress reactions or responses, become a product of the transaction between a person and a stimulus. It is therefore necessary to account for factors influencing the stimulus configuration and the psychologic makeup of the person when making an assessment of stress and coping. There are numerous manifestations of stress; these manifestations can be classified as affective, motor-behavioral, cognitive, or physiologic (Table 1-2).

The fight vs flight response, as described by Cannon[10] and popularized by Selye,[55] postulates that humans have an inherent capacity to survive in the presence of stressful stimuli by either avoiding the stimulus or by organizing the body's defenses to fight. The latter response is characterized by the General Adaptation Syndrome (GAS), a term coined by Selye, which outlines the physiologic response of the body to stress in three stages: (1) alarm, the initial stage during which the body's defensive forces such as adrenal stimulation are mobilized; (2) resistance, the second stage that reflects the adaptive efforts of the body; and (3) exhaustion, which occurs when adaptational energies are fully expended and ineffective in reducing the stress, with the result being death.

The elicitation of the alarm reaction in response to actual or perceived threat produces both hypothalamic- and humoral-mediated responses. As early as 1914, Cannon[10] described the humoral or adrenal medullary response to pain and major emotions as a sympathomimetic response to catecholamines. Alterations identified by Cannon included "a cessation of the activities of the alimentary canal, a notable shifting of the circulation from the great vessels of the abdomen to the lungs, heart, limbs, and central nervous system, an increased cardiac vigor, and an augmentation of the sugar content of the blood."[10] Manning and Piess[48] showed that a vagotomized cat, unable to respond to circulating catecholamines, responded to direct hypothalamic stimulation with a remarkably augmented force of myocardial contraction and lesser degrees of vasoconstriction and cardiac acceleration. Manning and Piess have suggested that the hypothalamus, along with the reticular activating system (RAS), mediate a barrage of parasympathetic and sympathetic stimuli that contribute to increased ventricular automaticity and increased frequency of sinoatrial discharge. The alarm response, whether it be hypothalamic- or humoral-mediated, produces psychophysiologic responses including increased heart rate (tachycardia), blood pressure, respiratory rate, oxygen consumption, and increased myocardial excitability, as well as sweating, peripheral vasoconstriction, nervousness, and increased skeletal muscle tone—all of which contribute to an increased metabolic demand. Survival depends on successful adaptation to this increased metabolic demand. The hypothalamic-mediated response to stress is merely postulated in humans because of obvious research limitations. Therefore the alarm response is most easily measured by the amount of serum catecholamines in the body and directly affects the intensity of the autonomic reaction.

The adaptational response of the resistance phase of the GAS is the body's attempt to preserve vital processes while minimizing the impact of the stressor. The body accomplishes this by optimizing the functions of essential organs such as the heart, lungs, and brain while concomitantly "shutting down" nonessential functions. During this stage the body adapts to the compensating mechanisms activated in the alarm reaction. At the physiologic level, adaptational changes may include (1) intrapulmonary shunting in response to ventilation-perfusion mismatches at the alveolar level; (2) increased ventilatory drive in the patient with acidemia; (3) alterations of kidney function in response to hypovolemia, acid-base imbalance, and inflammatory processes; and (4) stimulation of bone marrow that produces red blood cells in people living at high altitudes. This response produces a functional polycythemia—a true adaptational response of the human organism. Psychologic adaptations in response to the anxiety, fear, or grief that trigger the alarm reaction include all the defense mechanisms but most commonly feelings of denial, anger, depression, and resolution. These feelings are generally accompanied by cognitive and motor-behavioral cues.

Effective adaptation will promote the return of wellness in the person. Ineffective adaptation leads to the prolongation of the alarm reaction, ultimately producing exhaustion of the affected area, and can result in the death of a cell, target organ, or the entire organism. Based on this postulate, stress is measured by the resultant strain imposed on the body, which can be viewed as the residual alarm response after adaptation has been maximized. It must be kept in mind that maximal adaptation may be ineffective in reducing the alarm response in some instances. Lazarus recognizes this physiologic response as one type of reaction to stress and views cognitive appraisal as the mechanism of activation.

The fight/flight response is also thought to be caused by activation of the ergotropic zone in the anterior hypothalamus (Hess[35]). Gellhorn[29] noted that stimulation of the ergotropic zone produced pupillary dilation, increased blood pressure, increased heart and respiratory rates, and heightened motor excitability consistent with the sympathetic activity of the fight/flight reaction. The role of perception on hypothalamic-mediated responses to stressors has yet to be identified specifically.

Correlations between sudden death and emotions have been observed for centuries; in fact, emotions have been induced purposefully to cause death, as in the case of voodoo.[11,52] Engel[25] observed that sudden death occurred during and after strong emotional stress. Three common denominators observed in patients just before sudden death were overwhelming excitation; loss of control; and a sense of giving up, helplessness, or hopelessness.

Sudden cardiac death from ventricular fibrillation is the leading cause of death in the 35 to 65-year-old age group, according to epidemiologic data from the United States and Western Europe.[46]

The concepts underlying the fight/flight response and the associated neurochemical activity are particularly cogent in the discussion of ventricular fibrillation. Electrophysiologic studies by Ganong[27] and Marshall[50] indicate that sympathetic stimulation increases heart rate, force of contraction, and conduction velocity in atria, atrioventricular nodes, and ventricles. Further studies by Lown, Verrier, and Rabinowitz[46] have shown that enhanced sympathetic stimulation predisposes the laboratory animal to ventricular fibrillation by markedly lowering the cardiac vulnerable period threshold. They report, "We have recently demonstrated that when subpressor doses of norepinephrine are given or when the pressor response to large doses of the drug is controlled by exsanguination, norepinephrine produces significant and sustained reduction in the vulnerable period threshold" (p. 892).

In addition to examining the effects of catecholamines, considerable research has been done on the effects of hypothalamic and autonomic stimulation, as well as the effects of stellate ganglion innervation on cardiac vulnerability. Dikshit[23] demonstrated that cardiac irregularities could be produced by injecting acetylcholine, caffeine, and nicotine into the cerebral

Fig. 1-2. Physiologic responses to stress.
Adapted from Underhill, S.L.: Cardiac nursing, Philadelphia, 1982, J.B. Lippincott Co.