

Guidelines for critical care medicine training and continuing medical education

Todd Dorman, MD, FCCM; Peter B. Angood, MD, FCCM; Derek C. Angus, MB, ChB, FCCM; Terry P. Clemmer, MD, FCCM; Neal H. Cohen, MD, MPH, FCCM; Charles G. Durbin Jr, MD, FCCM; Jay L. Falk, MD, FCCM; Mark A. Helfaer, MD, FCCM; Marilyn T. Haupt, MD, FCCM; H. Mathilda Horst, MD, FCCM; Michael E. Ivy, MD; Frederick P. Ognibene, MD, FCCM; Robert N. Sladen, MB, ChB, FCCM; Ake N. A. Grenvik, MD, PhD, FCCM; Lena M. Napolitano, MD, FCCM

Objective: Critical care medicine trainees and faculty must acquire and maintain the skills necessary to provide state-of-the-art clinical care to critically ill patients, to improve patient outcomes, optimize intensive care unit utilization, and continue to advance the theory and practice of critical care medicine. This should be accomplished in an environment dedicated to compassionate and ethical care.

Participants: A multidisciplinary panel of professionals with expertise in critical care education and the practice of critical care medicine under the direction of the American College of Critical Care Medicine.

Scope: Physician education in critical care medicine in the United States should encompass all disciplines that provide care in the intensive care unit and all levels of training: from medical students through all levels of postgraduate training and continuing medical education for all providers of clinical critical care. The scope of this guideline includes physician education in the United States from residency through ongoing practice after subspecialization.

Data Sources and Synthesis: Relevant literature was accessed via a systematic Medline search as well as by requesting references from all panel members. Subsequently, the bibliographies of obtained literature were reviewed for additional references. In addition, a search of organization-based published material was conducted via the Internet. This included but was not limited to material published by the American College of Critical Care Medicine, Accreditation Council for Graduate Medical Education, Accreditation Council for Continuing Medical Education, and other primary and specialty organizations. Collaboratively and iteratively, the task force met, by conference call and in person, to construct the tenets and ultimately the substance of this guideline.

Conclusions: Guidelines for the continuum of education in critical care medicine from residency through specialty training and ongoing throughout practice will facilitate standardization of physician education in critical care medicine. (Crit Care Med 2004; 32:263-272)

KEY WORDS: critical care medicine; patient outcomes; intensive care unit utilization; continuing medical education; ethics

Medical education in the United States is undergoing a significant paradigm shift. Historically, medical education was designed to ensure exposure to the concepts required to practice

within that specialty. In the past few years, the Accreditation Council for Graduate Medical Education (ACGME) has mandated an outcomes approach and focus to education, and this is mirrored by the Accreditation Council for Continuing

Medical Education (ACCME) as well. These regulatory bodies now require the application of education science to medical education. Stated in other terms, they now require a documented needs assessment, followed by multiple-modality instruction with documented competency. Obviously, the expectation is that this approach will lead to better physicians and ultimately better patient care.

In response to this changing educational landscape, the American College of Critical Care Medicine (ACCM) created a task force to revise previously published ACCM educational guidelines for critical care medicine (CCM). The task force consisted of members from across the specialties so that the resultant guidelines would be broadly applicable. The task force decided early on to take a new approach to the scope of the guideline and its contents. Previously two guidelines existed, one for residents and one for subspecialty trainees. The task force believed

From Johns Hopkins Hospital, Department of Anesthesia and Critical Care Medicine, Baltimore, MD (TD); University of Massachusetts School of Medicine, Division of Trauma and Critical Care Medicine, Worcester, MA (PBA); University of Pittsburgh, Department of Critical Care Medicine, Pittsburgh, PA (DCA); LDS Hospital, Department of Critical Care Medicine, Salt Lake City, UT (TPC); University of California, San Francisco, Department of Critical Care Medicine, San Francisco, CA (NHC); University of Virginia Health System, Department of Anesthesiology, Charlottesville, VA (CGD); Orlando Regional Medical Center, Department of Emergency Medicine, Orlando, FL (JLF); Children's Hospital of Philadelphia, Pediatric Intensive Care Unit, Philadelphia, PA (MAH); Oregon Health Sciences University, Adult Critical Care Services, Portland, OR (MTH); Henry Ford Hospital, Division of Trauma Surgery, Detroit, MI (HMH); Bridgeport Hospital, Department of Surgery, Bridgeport, CT (MEI); National Institute of Health, Clinical Center/Critical Care Medicine

Department, Bethesda, MD (FPO); Columbia-Presbyterian Medical Center, College of Physicians and Surgeons, New York, NY (RNS); University of Pittsburgh, Department of Critical Care Medicine, Pittsburgh, PA (ANAG); University of Maryland Medical Systems, Department of Surgery, Baltimore, MD (LMN).

The American College of Critical Care Medicine (ACCM), which honors individuals for their achievements and contributions to multidisciplinary critical care medicine, is the consultative body of the Society of Critical Care Medicine (SCCM) that possesses recognized expertise in the practice of critical care. The College has developed administrative guidelines and clinical practice parameters for the critical care practitioner. New guidelines and practice parameters are continually developed, and current ones are systematically reviewed and revised.

Copyright © 2004 by Lippincott Williams & Wilkins

DOI: 10.1097/01.CCM.0000104916.33769.9A

that critical care physician education was a continuum from residency through subspecialty training and into continuing practice. The task force believed that critical care trainees and faculty must acquire and maintain the skills necessary to provide state-of-the-art clinical care to critically ill patients, to improve patient outcomes, optimize intensive care unit (ICU) utilization, and continue to advance the theory and practice of CCM. Consequently the scope of this guideline is broader than any previously published guidelines for physician education in CCM. In fact, we believe this is the first guideline to take this continuum approach to physician education.

In addition to the change in scope from previously published ACCM education guidelines, the task force believed that the content of the guideline should also mature to be built on educational principles. Previous approaches resulted in a long listing of content areas, and this task force believed that this was not sufficient as a modern guideline for education but rather should serve as an appendix to the guideline. The task force took this approach because it believed that learning in CCM is optimized when the learner is intimately exposed to and participates in the cognitive, practical, and technical aspects of critical care. The training should include a structured process that progressively transfers increasing levels of responsibility for decision making, ensures continued training in the practical aspects of care, and provides training and experience in the administrative and management functions of the ICU.

The guideline that follows, we believe, accomplishes the stated objectives and will serve as the guideline for critical care education for physicians in the United States. The guideline starts with a brief review of key components of the critical care environment and requirements of and for the program director. These sections are followed by sections dedicated to residents, subspecialty trainees, and those involved in the specialty practice of CCM. The appendix should serve as a resource for programmatic content.

THE CRITICAL CARE ENVIRONMENT

In addition to being an environment in which excellence in patient care is the foundation for learning to care for the critically ill and injured patient, the crit-

ical care environment should be an intensivist-directed, collaborative multiple-professional team model of patient-centered care for all ICU patients. This environment should include the following:

1. Strong, dedicated physician and nursing leadership committed to quality process and care and practice improvement.
2. All ICU personnel share a common vision regarding delivery of care and clinical practice improvement that is focused on what is best for the patient (patient-oriented/patient-centered environment).
3. Evidence-based protocols, clinical practice guidelines, and standards are routinely used and regularly reviewed to optimize patient care.
4. Processes and outcomes are routinely measured to continuously monitor the quality of care, to demonstrate the effectiveness of new improvement efforts, and to assess the effectiveness of formal training in CCM.
5. Physicians, nurses, clinical pharmacists, therapists, and others collaborate as colleagues both in the care of patients and in the practice improvement process.
6. Dialogues around the best way to care for patients and current protocol issues are common encounters, and challenges to the process of care are welcomed and respected.
7. A process for practice improvement is emphasized and easily identified in which problems are recognized and dealt with at the front line by all members of the multiple-professional team. Local teams should create solutions and implement protocols in a collaborative way that builds wholesome relationships among the unit's healthcare providers.
8. Patient, family, and surrogate decision makers are kept well informed about care plans, alternatives, and responses to therapies, and the patient, family, and surrogate decision makers' values are solicited and incorporated into the care plans.

The ICU should comply with ACCM guidelines including but not limited to the following:

1. Guidelines for ICU design
2. Guidelines for ICU admission, discharge, and triage or Guidelines for developing admission and discharge policies for the pediatric ICU
3. Critical care services and personnel: Recommendations based on a system of categorization into two levels of care
4. Guidelines for granting privileges for the performance of procedures in critically ill patients
5. Critical Care Delivery in the ICU: Defining Clinical Roles and the Best Practice Model
6. Future pertinent ACCM guidelines

TRAINING PROGRAM DIRECTOR QUALIFICATIONS

- A. The training program director must demonstrate a commitment to and competence in all aspects of CCM. Commitment is demonstrated by several factors, including all of the following: 1) board certification in CCM through an appropriate certification process, including the American Board of Pediatrics, the American Board of Anesthesiology, the American Board of Internal Medicine, or the American Board of Surgery; 2) development of an ACGME-accredited educational curriculum and program; 3) a significant and substantial amount of clinical time dedicated to the care of critically ill patients; and 4) involvement in national organizations that are involved in the care of critically ill or injured patients.
- B. The director must have the skills, interest, authority, and time required to fulfill teaching responsibilities in order to develop, implement, and achieve the educational goals of the training program. The director must have the time available to personally participate in the training of each trainee in the program. The director should also interact regularly with directors of other training programs within and outside of the institution to maintain the quality of the program and to en-

sure that the program has the depth and breadth of experience necessary for each trainee. The director should demonstrate commitment to the principles and practices of educational theory and methodologies.

- C. The director must maintain personal continuing education in CCM. The director maintains his or her own continuing education by reading appropriate literature, by participating in conferences at the regional and national levels relating to CCM, or through recertification.
- D. The director should participate in and have interest in medical research related to CCM. The director should actively participate in and/or provide an environment conducive to basic science, clinical, and/or translational research and should encourage all trainees to participate in and publish results of research and engage in scientific presentations of such results.
- E. The director should have appropriate training and expertise in ICU quality improvement processes. The director should have the ability to coordinate training in, and exposure to, ICU quality improvement processes for the trainees.
- F. The director should have appropriate training in the business, legal, moral, and ethical issues relevant to the care of the critically ill and injured. The director should have the ability to coordinate training and exposure to best business practice and moral and ethical issues.

PROGRAM CONTENT

CCM trainees and faculty are to acquire and maintain the skills necessary to provide state-of-the-art clinical care to critically ill patients, to improve patient outcomes, optimize ICU utilization, and continue to advance the theory and practice of CCM. Learning in CCM is optimized when the learner is intimately exposed to and participates in the cognitive

and technical aspects of care. The training should include a structured process that progressively transfers increasing levels of responsibility for decision making, ensures continued training in the practical aspects of care, and provides training and experience in the management and administrative functions of the ICU.

Education in CCM should encompass all disciplines that provide care in the ICU and all levels of training, from students through all levels of postgraduate training and continuing medical education (CME) for all providers of clinical critical care.

Medical student education in CCM is vitally important and presently almost nonexistent within current medical school constructs. Although important, it is outside the scope of this document. Consequently, this document starts with resident education in CCM.

I. Residents

On completion of an ACGME-approved graduate education program in a clinical specialty of medicine (e.g., anesthesiology, internal medicine, pediatrics, or surgery), each resident physician will have developed a measurable quantity of knowledge, learned a set of observable skills, demonstrated adequate decision making, and possess a caring and compassionate attitude for patients who are critically ill. Attainment of these goals is not to be necessarily misconstrued as conveying the ability to be an independent practitioner for critically ill or injured patients. Specifically, on completion of an ACGME-approved graduate education program, each resident physician will be able to perform the following:

Clinical.

Identify when a patient requires treatment best delivered in an ICU under the direction of a qualified intensivist.

Diagnose and stabilize patients with impending organ failure (respiratory, cardiac, neurologic, hepatic, gastrointestinal, hematologic, renal, etc.).

Identify the need for and initiate cardiopulmonary resuscitation.

Diagnose and prevent hemodynamic instability and/or initiate treatment for cardiogenic, traumatic, hypovolemic, and distributive shock.

Identify and initiate treatment for life-

threatening electrolyte and acid-base disturbances.

Suspect and initiate treatment for common poisonings.

Use data from appropriate invasive and noninvasive monitoring devices to titrate therapy in an ICU.

Understand basic infection control techniques.

Understand basic nutrition support principles.

Understand basic sedation and analgesia principles.

Understand basic concepts of therapeutic decision making and medication safety.

Recognize, use, and help integrate the unique skills of ICU nurses and ancillary personnel in caring for critically ill patients into the multiple-professional team model.

Consider ethical issues and patients' wishes in making treatment decisions.

Research.

Understand the basic methods for searching, reviewing, and evaluating the medical and scientific literature.

Support ongoing basic and clinical science protocols as well as process improvement protocols within the ICU.

Administrative.

Communicate effectively with families and all members of the healthcare team about ICU capabilities and patient-specific issues.

Communicate with and support patients, their families, and all members of the healthcare team through the physical and psychological complexities of critical illness.

Seek consultation, when appropriate, with specialty physicians in managing complex ICU problems.

Maintain good relationships with other healthcare providers.

Support initiatives to improve care of critically ill patients.

Understand the need for patient safety monitoring and error reduction strategies.

Understand the need for and help in the process of assessing patient and family satisfaction.

Understand basic compensation methodologies for critical care services.

Understand and ensure compliance with institutional and unit policies and procedures as well as regulatory policies from accreditors, regulators, and payers.

To achieve these objectives, all GME programs must ensure that each resident receives supervised exposure to an adequate number of critically ill patients. In general, these patients should be cared for by appropriately trained individuals in appropriately staffed and equipped ICUs. Since not all trainees will be exposed to the entire depth and breadth of clinical problems during their ICU experiences, a core critical care curriculum taught by clinical experts should supplement the clinical experience. Use of case-based education methodologies is encouraged. The program director should ensure that each resident achieves the previously listed competencies.

Subspecialty Training Residents (CCM Fellows)

On completion of a specialty training program in CCM, each physician will have developed a measurable quantity of advanced knowledge, performed and taught a set of observable skills, demonstrated advanced decision-making capability, demonstrated the ability to be the leader of the multiple-professional team model, and possessed an attitude of caring for patients who are critically ill. In addition, each physician will be able to perform the following:

Clinical.

Identify the need for and provide care for all critically ill adult and/or pediatric patients.

Provide resuscitation, including advanced techniques to any patients sustaining a life-threatening event.

Initiate critical care to stabilize and manage patients who require transport to another facility for a higher level of critical care support.

Initiate, manage, and wean patients from mechanical ventilation using a variety of techniques and ventilators.

Instruct other qualified caregivers and the lay public in the theory and techniques of cardiopulmonary resuscitation.

Treat cardiogenic, traumatic, hypovolemic, and distributive shock using

conventional and state-of-the-art approaches.

Recognize the potential for multiple organ failure and institute measures to avoid or reverse this syndrome.

Identify life-threatening electrolyte and acid-base disturbances, provide treatment, and monitor outcome.

Diagnose malnutrition and use and monitor advanced nutrition support methodologies.

Diagnose common and uncommon poisonings and provide all necessary treatment.

Instruct others in appropriate use and monitoring of conscious and deep sedation and use advanced pain management strategies.

Select, place, and use appropriate invasive and noninvasive monitors for titrating therapy in any critically ill patient. Prioritize complex data to support an action plan.

Use and help enforce advanced methods of infection control.

Use medication safe practice guidelines and determine cost-effectiveness of therapeutic interventions.

Use and increase the skills of ICU nurses and ancillary personnel in caring for critically ill patients by acting as the ICU team leader.

Initiate consultation with other specialist physicians and negotiate a joint clinical plan in managing complex ICU problems.

Initiate discussions involving ethical issues and patients' wishes in making treatment decisions, using advance directives, and using other methods.

Communicate effectively with patients, families, and other involved members of the healthcare team about all treatment decisions and patient prognosis.

Support patients, their families, and other members of the healthcare team through the trauma of critical illness.

Research.

Analyze current and novel clinical practices by identifying relevant scientific publications and evaluating them using evidence-based medicine techniques.

Support ongoing basic science or clinical studies designed to evaluate and improve the understanding of critical illness and the care of the critically ill.

Administrative.

Evaluate current ICU hospital policies and suggest improvements.

Triage critically ill patients to optimize care delivery within the institution.

Improve resource utilization and maintain patient care quality by facilitating triage of patients to limited institutional critical care beds and caregivers.

Develop programs and change unit practice to improve care of critically ill patients.

Develop programs for patient safety monitoring and error reduction.

Actively participate in quality assurance processes, including mortality and morbidity conferences, process improvement teams, and Joint Commission on Accreditation of Healthcare Organizations preparation.

Support the process of assessing patient and family satisfaction and participate in tool development and implementation.

Encourage and enhance good relationships with other healthcare providers.

Understand advanced concepts important for compensation of critical care services and contractual issues related to providing critical care services and performing the business of medicine.

Develop skills for teaching critical care.

To achieve these objectives, all ACGME Critical Care Advanced Training Programs must ensure that each CCM resident (fellow) receives the appropriate level of supervised exposure to an adequate number of critically ill patients, participates in an organized didactic program, develops and executes a guided research project, and is allowed to develop leadership and management skills in caring for the critically ill in an ICU. A graduated progression during the subspecialty training should lead the physician to increasing responsibility and independent decision making. It is essential that this training and experience occur in appropriately staffed and equipped ICUs under the direction of certified critical care physicians. Since not all clinical problems will occur during the advanced training program, an exhaustive, detailed didactic curriculum must supplement the clinical experience. Each CCM resident (fellow) has unique strengths and weaknesses, and it is the responsibility of the program to ensure

that each CCM resident (fellow) achieves these competencies. The program must evaluate its effectiveness in developing competent intensivists (see definition in the ACCM guideline entitled, "Critical care delivery in the intensive care unit: Defining clinical roles and the best practice model") and make changes based on these evaluations.

II. Specialty Practice of Critical Care Medicine

Physicians engaged in the specialty practice of CCM will develop an ever-increasing, measurable quantity of knowledge; regularly perform and teach an increasingly broader set of skills; continue to demonstrate advanced, ethical decision making; and serve as a role model for a compassionate and caring attitude toward patients who are critically ill. They will serve as role models for the intensivist-directed multiple-professional team model of patient-centered care for all ICU patients. In addition, each critical care physician will perform the following:

Clinical.

Continue to augment his or her knowledge by assimilating appropriate new peer-reviewed published medical literature through self-directed learning.

Develop and participate in CME activities designed to enhance critical care knowledge.

Teach others to identify the need for and provide care for all critically ill adult and/or pediatric patients.

Continue to provide and teach cardiopulmonary and cerebral resuscitation including advanced techniques for all patients sustaining life-threatening events.

Introduce and teach others new methods and use of devices for management of patients in respiratory failure.

Develop and evaluate curriculum changes for ICU caregivers, fellows, and residents.

Diagnose and treat a sufficient number of patients with critical illness using conventional and state-of-the-art approaches to maintain clinical proficiencies.

Teach others to select, place, and use appropriate monitors for titrating therapy in any critically ill patient by demonstrating these skills in daily practice.

Teach others infection control and monitor infection control practices of the unit.

Teach medication safety and cost-effectiveness of therapeutic decision making.

Increase the skills of ICU nurses and ancillary personnel in caring for critically ill patients by acting as the ICU team leader and providing in-service education.

Model effective communication with patients, families, and members of the healthcare team about treatment decisions and patient prognosis.

Support patients, their families, and other members of the healthcare team through the trauma of critical illness.

Develop collaborative and productive relationships with other specialist physicians and model joint clinical planning in managing complex ICU problems.

Identify ethical issues and lead discussions involving patients, families, and members of the healthcare team in making treatment decisions.

Research.

Advance the clinical practice of CCM using evidence-based medicine techniques and through the dissemination of findings by publishing case reports and clinical and basic science research.

Develop and continue ongoing basic science and clinical studies designed to evaluate and improve care of the critically ill.

Administrative.

Evaluate, modify, and approve ICU hospital policies.

Improve resource utilization and maintain patient care quality by planning for future needs for institutional and regional critical care resources.

Develop programs and change unit, institution, and regional practice to improve care of critically ill patients.

Develop programs and document improvement in patient safety monitoring and error reduction.

Use existing tool sets to assess patient and family satisfaction and direct the development of new tools when appropriate.

Develop high-quality relationships with other healthcare providers.

Teach the business of medicine.

To achieve these continuing competencies, all active intensivists must demonstrate a commitment to professional

development and lifelong learning. This commitment can be assessed by achieving board certification and recertification in CCM; by regular attendance at CME activities and individual self-studies; by publications related to education or research studies; or by attestations from colleagues, peers, patients, students, residents, fellows, nurses, allied health professionals, and hospital administrators that include quality reports, patient lists, and outcome statistics.

APPENDIX

The following lists of credentials and cognitive and procedural skills are not intended to serve as a complete list of all topics that should or must be covered during CCM training or CME in CCM. The lists are only intended to serve as guides for both programs and individuals participating in the educational process. Many unique illnesses may exist in particular populations (i.e., pediatrics) that are less well represented in this list, and we again remind the reader that this list is in no way intended to be a complete list of all topics.

I. Specific Credentials

Each trainee should achieve provider and/or instructor status in one or more of the following:

1. Advanced Cardiac Life Support
2. Advanced Trauma Life Support
3. Pediatric Advanced Life Support
4. Fundamentals of Critical Care Support

II. Cognitive Skills

Acquisition of the following cognitive skills by trainees could be ensured by the training director through the use of any of a number of techniques, including didactic lectures, journal club sessions, and illustrative case reports.

- A. Cardiovascular Physiology, Pathology, Pathophysiology, and Therapy
 1. Shock (hypovolemic, neurogenic, septic, cardiogenic) and its complications
 2. Myocardial infarction and its complications
 3. Cardiac rhythm and conduction disturbances

Guidelines for the continuum of education in critical care medicine from residency through specialty training and ongoing throughout practice will facilitate standardization of physician education in critical care medicine.

4. Indications for and types of pacemakers
5. Pulmonary embolism—thrombus, air, fat, amniotic
6. Pulmonary edema—cardiogenic, noncardiogenic
7. Cardiac tamponade and other acute pericardial diseases
8. Acute and chronic life-threatening valvular disorders
9. Acute aortic and peripheral vascular disorders, including arteriovenous fistulas
10. Acute complications of cardiomyopathies and myocarditis
11. Vasoactive and inotropic therapy
12. Pulmonary hypertension and cor pulmonale
13. Complications of angioplasty
14. Principles of oxygen transport and utilization
15. Hemodynamic effects caused by ventilatory assist devices
16. Thrombolytic and anticoagulant therapy
17. Perioperative management of patient undergoing cardiovascular surgery
18. Recognition, evaluation, and management of hypertensive emergencies and urgencies
19. Congenital heart disease and the physiologic alterations with surgical repair
20. Noninvasive methods of cardiac

output assessment (i.e., aortic Doppler, indicator dilution techniques, etc.)

B. Respiratory Physiology, Pathology, Pathophysiology, and Therapy

1. Acute respiratory failure
 - a. Hypoxemic respiratory failure including acute respiratory distress syndrome
 - b. Hypercapnic respiratory failure
 - c. Acute on chronic respiratory failure
2. Status asthmaticus
3. Smoke inhalation, airway burns
4. Aspiration
5. Chest trauma (e.g., flail chest, pulmonary contusion, rib fractures)
6. Bronchopulmonary infections including bronchiolitis
7. Upper airway obstruction
8. Near drowning
9. Bronchopleural fistulas
10. Pulmonary mechanics and gas exchange
11. Oxygen therapy
12. Hyperbaric oxygenation
13. Mechanical ventilation
 - a. Pressure and volume modes of mechanical ventilators
 - b. Positive end-expiratory pressure, intermittent mandatory ventilation, continuous positive airway pressure, high-frequency ventilation, inverse ratio ventilation, pressure-support ventilation, volume support (airway pressure release ventilation, pressure-regulated volume control ventilation), negative pressure ventilation, differential lung ventilation, pressure control and noninvasive ventilation, spilt lung ventilation, one-lung ventilation
 - c. Indications for and hazards of mechanical ventilation
 - d. Barotrauma and volutrauma
 - e. Criteria for extubation and weaning techniques
 - f. Extracorporeal membrane oxygenation
 - g. Permissive hypercapnia

- h. Liquid ventilation
- i. Pulmonary surfactant therapy
- j. High-frequency oscillatory ventilation

14. Airway maintenance

- a. Emergency airway management
- b. Endotracheal intubation
- c. Tracheostomy, open and percutaneous
- d. Long-term intubation vs. tracheostomy

15. Ventilatory muscle physiology, pathophysiology, and therapy, including polyneuropathy of the critically ill and prolonged effect of neuromuscular blockers

16. Pleural diseases

- a. Empyema
- b. Pleural effusion
- c. Pneumothorax
- d. Hemothorax

17. Pulmonary chylothorax, hemorrage, and hemoptysis

18. Nitric oxide and prostaglandin therapies

19. Noninvasive ventilation

20. Positional therapy (i.e., prone position, rotational therapy)

C. Renal Physiology, Pathology, Pathophysiology, and Therapy

1. Renal regulation of fluid balance and electrolytes
2. Renal failure: Prerenal, renal, and postrenal
3. Derangements secondary to alterations in osmolality and electrolytes
4. Acid-base disorders and their management
5. Principles of renal replacement therapy and associated methodologies (hemodialysis, peritoneal dialysis, ultrafiltration, continuous arteriovenous hemofiltration, and continuous veno-venous hemofiltration)
6. Interpretation of urine electrolytes
7. Evaluation of oliguria
8. Drug dosing in renal failure
9. Rhabdomyolysis
10. Systemic diseases that involve the kidney (thrombotic thrombocyto-

- penic purpura, hemolytic uremic syndrome)
- D. Central Nervous System Physiology, Pathology, Pathophysiology, and Therapy
 1. Coma
 - a. Metabolic
 - b. Traumatic
 - c. Infectious
 - d. Mass lesions
 - e. Vascular-anoxic or ischemic
 - f. Drug induced
 - g. Assessment and prognosis
 2. Hydrocephalus and shunt function and dysfunction
 3. Psychiatric emergencies
 4. Perioperative management of patient undergoing neurologic surgery
 5. Brain death evaluation and certification
 6. Diagnosis and management of persistent vegetative states
 7. Management of increased intracranial pressure, including intracranial pressure monitors
 8. Status epilepticus
 9. Neuromuscular disease causing respiratory failure
 - a. Guillain-Barré
 - b. Amyotrophic lateral sclerosis
 - c. Myasthenia gravis
 - d. Myopathies (Duchenne's, etc.)
 - e. Neuropathy of critical illness
 10. Traumatic and nontraumatic intracranial bleed
 - a. Subarachnoid
 - b. Intracerebral
 - c. Epidural
 - d. Others (subdurals)
 - e. Traumatic brain injury
 - f. Axonal shear injury
 11. Conscious and deep sedation
 12. Pain management: Intravenous, oral, transdermal, and regional and axial
 13. Neuromuscular blockade: Use, monitoring, and complications
- E. Metabolic and Endocrine Effects of Critical Illness
 1. Colloid osmotic pressure
 2. Nutritional support
 - a. Enteral and parenteral
 - b. Evaluation of nutritional needs including indirect calorimetry
 - c. Immunonutrition and specialty formulas
 3. Endocrine
 - a. Disorders of thyroid function (thyroid storm, myxedema coma, sick euthyroid syndrome)
 - b. Adrenal crisis and insufficiency (primary and secondary)
 - c. Disorders of antidiuretic hormone metabolism
 - d. Diabetes mellitus
 1. Ketotic and nonketotic hyperosmolar coma
 2. Hypoglycemia
 - e. Pheochromocytoma
 - f. Insulinoma
 - g. Disorders of calcium, magnesium, and phosphate balance
 - h. Inborn errors of metabolism
 4. Electrolyte disorders including Na, K, Mg, Ca, PO₄.
 5. Glucose management
- F. Infectious Disease Physiology, Pathology, Pathophysiology, and Therapy
 1. Antibiotics
 - a. Antibacterial agents including aminoglycosides, penicillins, cephalosporins, quinolones, and newer emerging classes of antibiotics
 - b. Antifungal agents
 - c. Antituberculosis agents
 - d. Antiviral agents
 - e. Agents for parasitic infections
 2. Infection control for special care units
 - a. Development of antibiotic resistance
 - b. Universal precautions
 - c. Isolation and reverse isolation
 3. Anaerobic infections
 4. Sepsis definitions (sepsis, severe sepsis, septic shock)
 5. Systemic inflammatory response syndrome
 6. Tetanus
 7. Hospital-acquired and opportunistic infections in the critically ill
- G. Physiology, Pathology, Pathophysiology, and Therapy of Acute Hematologic and Oncologic Disorders
 1. Acute defects in hemostasis
 - a. Thrombocytopenia/thrombocytopenia
 - b. Disseminated intravascular coagulation
 2. Anticoagulation; fibrinolytic therapy
 3. Principles of blood component therapy
 - a. Packed red blood cell transfusions
 - b. Fresh frozen plasma transfusions
 - c. Platelet transfusions
 - d. Cryoprecipitate transfusions
 - e. Specific coagulation factor concentrates
 - f. Albumin, plasma protein fraction
 - g. Hemoglobin substitutes
 - h. Pharmacologic agents that modify the need for transfusion (i.e., aminocaproic acid, aprotinin)
 - i. Erythropoietin
 4. Acute hemolytic disorders including thrombotic microangiopathies
 5. Acute syndromes associated with neoplastic disease and antineoplastic therapy
 6. Sickle cell crisis and acute chest syndrome
 7. Plasmapheresis
 8. Adverse reactions to antimicrobial agents
 9. ICU support of the immunosuppressed patient
 - a. Acquired immunodeficiency syndrome
 - b. Transplant
 - c. Oncologic
 10. Infectious risks to healthcare workers
 11. Evaluation of fever in the ICU patient
 12. Biological modifiers (activated protein C, tissue factor, etc.)
 13. Mechanisms of antibiotic resistance

8. Prophylaxis against thromboembolic disease
9. ICU-acquired anemia
- H. Physiology, Pathology, Pathophysiology, and Therapy of Acute Gastrointestinal, Genitourinary, and Obstetrical-Gynecologic Disorders
 1. Acute pancreatitis with shock
 2. Upper gastrointestinal bleeding, including variceal bleeding
 3. Lower gastrointestinal bleeding
 4. Acute and fulminant hepatic failure
 5. Toxic megacolon and pseudo-obstruction syndromes (i.e., Ogilvie's)
 6. Acute perforations of the gastrointestinal tract
 7. Ruptured esophagus
 8. Acute inflammatory diseases of the intestine
 9. Acute vascular disorders of the intestine, including mesenteric infarction
 10. Obstructive uropathy, acute urinary retention
 11. Urinary tract bleeding
 12. Toxemia of pregnancy, amniotic fluid embolism, HELLP (hemolysis, elevated liver function tests, and low platelet count) syndrome, ovarian hyperstimulation
 13. Hydatidiform mole
 14. Perioperative management of surgical patients
 15. Stress ulcer prophylaxis
 16. Drug dosing in hepatic failure
 17. Acalculous cholecystitis
 18. Postoperative complications including fistulas, wound infection, and evisceration
 19. Placenta previa and abruption
 20. Peripartum cardiomyopathy
- I. Environmental Hazards
 1. Drug overdose and withdrawal
 - a. Barbiturates
 - b. Narcotics
 - c. Salicylates
 - d. Alcohols
 - e. Cocaine
 - f. Tricyclic antidepressants
 - g. Acetaminophen
 - h. Others
 2. Temperature-Related Injuries
 - a. Hyperthermia, heat shock
 - b. Hypothermia, frostbite
 3. Envenomation
 4. Altitude sickness
 5. Decompression sickness
 6. Skin and wound care
 7. Biological and chemical terrorism
 8. Radiation exposure
- J. Immunology and Transplantation
 1. Principles of transplantation (organ donation, procurement, preservation, transportation, allocation, implantation, maintenance of organ donors, national organization of transplantation activities)
 2. Immunosuppression
 3. Organ transplantation: Indications preoperative and postoperative care
 4. Transplant-related infectious disease
- K. Trauma, Burns
 1. Initial approach to the management of multiple system trauma
 2. Central nervous system trauma (brain and spinal cord)
 3. Skeletal trauma, including the spine and pelvis
 4. Chest trauma, blunt and penetrating
 5. Abdominal trauma, blunt and penetrating
 6. Crush injury
 7. Burns
 8. Electrical injury
- L. Monitoring, Bioengineering, Biostatistics
 1. Prognostic indexes, severity, and therapeutic intervention scores
 2. Principles of electrocardiographic monitoring, measurement of skin temperature and resistance, transcutaneous measurements
 3. Invasive hemodynamic monitoring
 - a. Principles of strain gauge transducers
 - b. Signal conditioners, calibration, gain, adjustment
 - c. Display techniques
 - d. Principles of arterial, central venous, and pulmonary artery pressure catheterization and monitoring
 - e. Assessment of cardiac function and derived hemodynamic variables
4. Noninvasive hemodynamic monitoring
5. Electrical safety
6. Thermoregulation
7. Central nervous system brain monitoring (intracranial pressure, cerebral blood flow, cerebral metabolic rate, electroencephalogram, jugular venous bulb oxygenation, transcranial Doppler)
8. Respiratory monitoring (airway pressure, intrathoracic pressure, tidal volume, pulse oximetry, deadspace/tidal volume ratio, compliance, resistance, capnography, pneumotachography)
9. Metabolic monitoring (oxygen consumption, carbon dioxide production, respiratory quotient, indirect calorimetry)
10. Use of computers in critical care units
- M. Ethics
 1. Consent
 2. Study enrollment
 3. End-of-life decision making and care
 4. Organ procurement
 5. Outcome and futility
 6. Quality of end of life
- N. Administration
 1. Team building
 2. Contracting care
 3. Patient triage
 4. Physician, nurse, and ancillary staff staffing models
 5. Documentation compliance and billing
 6. Patient safety
- O. Genetic
 1. Congenital disease (trisomy, etc.)
 2. Storage diseases (Hurlers, etc.)
 3. Polymorphisms
- P. Pharmacology
 1. Pharmacokinetics
 2. Pharmacodynamics

3. Safe medication practice
4. Drug dosing adjustments in hepatic disease
5. Drug dosing adjustments in renal disease

Core Procedural Skills for Residents

In addition to practical training in the following procedural skills, the resident must have an understanding of the indications, contraindications, complications, and pitfalls of these interventions. Due to the variability of individual training programs, practical experience may be limited for some procedures.

A. Airway Management

1. Maintenance of an open airway in the nonintubated patient
2. Ventilation by bag-mask
3. Tracheal intubation
4. Management of pneumothorax

B. Circulation

1. Arterial puncture and cannulation
2. Insertion of central venous catheters
3. Pericardiocentesis in acute tamponade
4. Dynamic electrocardiogram interpretation
5. Cardioversion and defibrillation
6. Pulmonary artery catheterization
7. Transcutaneous pacing
8. Electrocardiographic monitoring

C. Additional Procedures

1. Thoracentesis
2. Paracentesis
3. Endoscopy
4. Bronchoscopy

Critical Care Educational Web Sites

The critical care educational Web sites listed next may be useful in training residents in multidisciplinary critical care. This list is not fully inclusive of all possible critical care educational Web sites. The ACCM and the SCCM do not specifically endorse these Web sites and take no individual responsibility for their content.

Disclaimer of Liability. The user assumes all responsibility and risk for the use of these Web sites and the Internet generally. Under no circumstances, including negligence, shall anyone involved in creating or maintaining these Web sites be liable for any direct, indirect, incidental, special, or consequential damages or lost profits that result from the use or inability to use the Web site and/or any other Web sites that are linked to these sites. Nor shall they be liable for any such damages including, but not limited to, reliance by a member or visitor on any information obtained via the Web site or that result from mistakes, omissions, interruptions, deletion of files, viruses, errors, defects, or any failure of performance, communications failure, theft, destruction, or unauthorized access.

www.sccm.org (Society of Critical Care Medicine)

www.nlm.nih.gov/medlineplus/criticalcare.html (Medline-plus health information on critical care—National Library of Medicine)

www.chestnet.org (American College of Chest Physicians)

www.chestnet.org/education/pccu/index.html (Pulmonary and Critical Care Update Online)

www.pacep.org (Pulmonary Artery Catheter Education Project)

www.asahq.org (American Society of Anesthesiologists)

www.facs.org (American College of Surgeons)

www.acep.org (American College of Emergency Physicians)

www.ascca.org (American Society of Critical Care Anesthesiologists)

www.aacn.org (American Association of Critical Care Nurses)

www.aps-spr.org (American Society of Pediatrics and the Society for Pediatric Research)

www.acponline.org (American College of Physicians, American Society of Internal Medicine)

www.canadiancriticalcare.org (Canadian Critical Care Society)

www.esicm.org (European Society of Intensive Care Medicine)

www.esicm.org/pact/default.asp (Patient-Centered Acute Care Training—

Multidisciplinary Distance Learning Program for Critical Care)

www.thoracic.org (American Thoracic Society)

www.cochrane.org (The Cochrane Collaboration and Cochrane Library—evidence-based reviews)

www.mdchoice.com (Advanced cardiac life support and pediatric advanced life support critical care simulators, Emergency Medicine and Critical Care Center)

www.medscape.com (Medscape—from WebMD)

www.ccforum.com (The Critical Care Forum)

www.intensivecare.com (Supporting evidence-based practice in critical care)

www.trauma.org (Interactive forum for trauma care providers)

www.vitruahospital.org (Virtual Hospital, University of Iowa College of Medicine)

www.evidencebased.net (Evidence-based decision making)

www.clinicalevidence.org (Clinical Evidence)

www.ahcpr.gov (Agency for Healthcare Research and Quality)

www.guideline.gov (National Guideline Clearinghouse)

www.anes.upmc.edu/mcctp/jc.html (Multidisciplinary Critical Care Training Program, University of Pittsburgh School of Medicine)

www.acgme.org (Accreditation Council for Graduate Medical Education)

www.accme.org (Accreditation Council for Continuing Medical Education)

www.emcreg.org (Emergency Medicine Cardiac Research and Education Group—see Medical Links)

www.nise.mL (National Initiative in Sepsis Education)

www.icusrs.org (Intensive care unit safety reporting system)

www.cdc.gov (Centers for Disease Control and Prevention)

Clinical Trials Networks in Critical Care

www.intensivecare.com/PALICI.html (Pediatric Acute Lung Injury and Sepsis Investigators)

www.ardsnet.org (Acute Respiratory Distress Syndrome Clinical Network)

www.critcare.lhsc.on.ca/cc/index.html (Canadian Critical Care Trials Group)

www.anzics.herston.uq.edu.au/asi/ClinicalTrials/home.html (Australia and New Zealand Intensive Care Society Clinical Trials Group)

Evidence-Based Critical Care Journal Clubs

www.thoracic.org/assemblies/mL/ccjframe.html (American Thoracic Society Critical Care Journal Club)

www.ahsn.lhsc.on.ca (Critically appraised papers in adult critical care, Southwestern Ontario Regional Academic Health Science Network)

www.pedscm.wustl.edu/Ebjournal_club.html (Pediatric Critical Care Medicine Evidence-Based Journal Club)

www.criticalcarerounds.ca (Internet journal from the Canadian Critical Care Society)

www.ssm.gov.mo/cimc99/links1.htm (Links to a large number of critical care Web sites internationally)