

Organization and Physician Education in Critical Care Medicine

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The Emergency and Critical Care Medicine System

THE TERM "critical care medicine" (CCM), introduced in the late 1960's as a synonym for "acute medicine" (a term used earlier in the United States) or "reanimation" (a European term), has been defined in various ways. We consider CCM to be the triad of 1) resuscitation; 2) emergency care for life threatening conditions; 3) intensive care, *i.e.*, those aspects of service, teaching, and inquiry anywhere in the emergency and critical care medicine (ECCM) system (table 1).^{92-94,105} Others have used a more physician-oriented geographic definition, equating CCM only with "intensive care," *i.e.*, the management of patients in intensive care units (ICU's).^{34,76,115} The latter definition equates the "CCM physician" with the "intensivist"⁸⁵ and is predicated on the assumption that all patients admitted to ICU's should be critically ill or injured, whereas only 2-5 per cent of patients seen in emergency departments (ED's) are in critical condition.⁹⁴ We discuss the broader concept first, and later focus on the ICU and the intensivist.

Historically, effective respiratory resuscitation techniques were established in the 1950's,^{32,33,82} external cardiac resuscitation⁵³ and cardiopulmonary resuscitation^{47,63,89} in the 1960's, and brain resuscitation methods are beginning to evolve.^{60,68,96,97,98,101} These developments of emergency resuscitation were accompanied by the introduction of long-term life-support techniques (intensive care) for respiratory failure,^{10,13,-24,25,34,45,46,73,84} cardiac failure,^{2,26,58,104} shock and trauma,^{17,102,114} renal failure,⁹ and multiple-organ failure for adults^{29,51,79,83,108,115,117} and for children.^{7,48,111}

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Received from the Department of Anesthesiology/Critical Care Medicine, University Health Center of Pittsburgh, Pittsburgh, Pennsylvania 15261. Supported in part by the National Institutes of Health/Heart Lung Institute, contract 1-HR 42965 (1975), and grant GM 01871 (1965-70). Material in this chapter is in part adapted from Chapter 4 of *Public Health Aspects of Critical Care Medicine and Anesthesiology* (Safar P, editor; Philadelphia, F. A. Davis, 1974).

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Key words: Physician education; Emergency medicine; Resuscitation; Critical care medicine; Intensive care (unit); Public health; Cardiopulmonary resuscitation; Health manpower; Health care evaluation; Education evaluation; Medical education; Residency training; Fellowship training.

Almost simultaneously, organizational and educational developments for most components of the ECCM system were initiated: 1) basic improvement in ambulance services,^{35,37,50,87,91} 2) prehospital emergency cardiac care,^{16,27,62,70} 3) national standards for ambulance design and equipment,^{64,87,90} 4) basic emergency medical technicians' (EMT's) training,^{15,65,91} 5) advanced EMT's (paramedic) training and general mobile intensive care,^{19,20,37,62,66} 6) recommendations for development of ECCM systems,^{37,54,72,77,88,94,100,105} 7) recommendations for hospital categorization,^{5,14,88,120} 8) founding of the American College of Emergency Physicians (ACEP) and the University Association of Emergency Medical Services (UAEMS) in 1968, and 9) founding of the multidisciplinary Society of Critical Care Medicine (SCCM) in 1970.^{96,103,105,106,116}

Today in the United States, approximately 800,000 persons die each year from conditions that represent medical and surgical emergencies: there are about 600,000 deaths due to ischemic heart disease, 100,000 accidental deaths (about 50,000 being the result of trauma due to traffic accidents), and 100,000 due to miscellaneous medical emergencies.^{67,94} In addition, each year at least 500,000 of the 50 million accidentally injured suffer lasting disability and thereby become a multi-billion dollar burden on the economy. Relatively inexpensive effective emergency resuscitation can often prevent the need for expensive intensive care.^{28,93} Survivors who have severely damaged central nervous systems may cost society as much as \$1 million per lifetime.

Data suggest that with maximally feasible implementation of present knowledge and technology in CCM through well-coordinated regional systems (table 1), at least 100,000 of these deaths each year could be prevented.^{11,26,27,36,62,88,93,94,100} It is generally agreed that this has not been accomplished for a variety of reasons. Among these are fragmented and uncoordinated efforts for improvement, public ignorance or apathy, local political obstacles, and confused or non-existing authority for health care.^{93,99,100,107}

The ECCM system is only as strong as its weakest component, and the earlier modern life support is begun, the greater the patient's chance for quality survival without exorbitant cost. Numerous national committees, commissions, and agencies have developed guidelines for the system.^{20,22,41,63-66,88,93,94,100} Principal deficiencies still include inadequate physi-

cian direction of prehospital care, frequent patient transfer to the nearest but not necessarily the most appropriate hospital, and poor resuscitation in ED's and hospital wide. The national recommendations and standards have yet to be evaluated. Methods for testing the effects of education, organization, and other means of influencing care are still imperfect, complicated, and expensive.^{15,74,118,119}

The ED physician, represented by the ACEP, has evolved in recent years because generalists have failed to cover the nation's primary care needs; because traditional specialists have failed to cover emergency care needs in many community hospitals' ED's; and because our non-system has so far prevented more centralized care of special emergency problems. The ED physician should be a competent generalist with skills in resuscitation. For advanced resuscitation, he should call the CCM physician and other appropriate specialists to the ED for help.

The CCM physician is a specialist in Anesthesiology, Emergency Medicine, Internal Medicine, Pediatrics, or Surgery, with special competence and involvement in emergency and long-term resuscitation.^{85,92,105,106} CCM is a multidisciplinary endeavor that crosses traditional departmental and specialty barriers, since no one physician possesses the full range of all skills and knowledge ICU patients may require.^{92,105,106,115} The SCCM, now with 650 members, estimates the ICU staff physician manpower needs to be at least 2,800 ICU directors and co-directors to supervise the general ICU's in the 1,400 acute care general hospitals in the United States with more than 200 beds each. While SCCM started as a small club of primarily university clinician-scholars and scientists, at present most SCCM members are clinically oriented physicians (anesthesiologists 36 per cent, internists 25 per cent, pediatricians 4 per cent, and surgeons 14 per cent).

Although there is no dispute that the anesthesiologist's primary role is to provide safe, effective anesthesia service, there have been controversies about the extent to which anesthesiologists should be involved in the necessary transfer to medicine at large of the resuscitation and life-support expertise gained in the operating room. Those in favor of involvement of anesthesiologists beyond the operating room contrast the 20 per cent mortality among ICU patients with the estimated 0.05 per cent anesthesia-related mortality.¹¹⁴⁻¹¹⁶

The American Society of Anesthesiologists Committee on Acute Medicine, founded in 1965,⁸⁸ initially encountered considerable opposition from some academic and political leaders of this specialty to anesthesiologists' extra-operating-room clinical involve-

TABLE 1. The Emergency and Critical Care Medicine Delivery System, Components*

1. Scene: Recognition of emergency
Aid by bystanders†
2. Scene: Initiation of response system†
3. Scene: Resuscitation, stabilization by members of the system†
4. Transportation with life support by members of the system†
5. Emergency department (<5 per cent of the patients are critical)
Patient care base for emergency physicians
6. Operating room
Patient care base for anesthesiologists and surgeons
7. Intensive care unit (100 per cent of the patients should be critical)
8. Organization, communication of 1-7‡
9. Planning, education, evaluation of 1-7‡
10. Research (laboratory, clinical, and public health)

* Components of EMS system proposed by the authors (37,94) are similar, but not identical, to those published subsequently by the U.S. Department of Health, Education and Welfare, EMS Division.

† Prehospital components under ED or ICU physician direction by radio.

‡ Components for coordination of the system, to be under the combined leadership of emergency and CCM physicians.

ment and to their moving into territories "claimed" by others.^{55,71} Nevertheless, some anesthesiologists were primarily responsible for the modern developments in resuscitation and intensive care, and a few helped initiate and develop EMS national standards and prehospital emergency care delivery methods. A survey of our specialty in the 1960's considered critical care involvement a prime attraction to the specialty.³¹ Community hospital anesthesiologists have be-

GLOSSARY

Abbreviation	Definition
ACEP	American College of Emergency Physicians
ALS	Advanced Life Support (<i>cf.</i> CPR, ABCD)
BLS	Basic Life Support (<i>cf.</i> CPR, ABC)
CCM	Critical Care Medicine
CCU	Coronary Care Unit
CPR	Cardiopulmonary resuscitation
CPR, ABC	Cardiopulmonary resuscitation: A, airway control; B, breathing; C, circulation, <i>i.e.</i> , BLS
CPR, ABCD	Cardiopulmonary resuscitation: ABC (above) and D, definitive therapy (restarting of spontaneous circulation plus immediate post-resuscitation care); <i>i.e.</i> , ALS
ECCM	Emergency and Critical Care Medicine
ED	Emergency Department
EM	Emergency Medicine
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
FTE	Full-time equivalent
ICU	Intensive Care Unit
MICU	Mobile Intensive Care Unit
SCCM	Society of Critical Care Medicine
UAEMS	University Association of Emergency Medical Services

TABLE 2. Decrease of ICU Mortality with Increased Physician Staffing, University Health Center of Pittsburgh

	Number of FTE CCM Physicians		Percentage of Patients Died in ICU ¹			Patients with Mechanical Ventilation, Per Cent of ICU Admissions*
	Fellows	Staff	From All Causes	From Respiratory Causes	Of Those on Mechanical Ventilation	
Adult ICU ⁹²						
1965	2	0.5	20	3.3	49	20
1973	5	2.0	20	2.2	30	70
Pediatric ICU ⁴⁸						
1967	1	0	26	6.3	41	14
1972	3	2	15	0.8	30	46

* Reflects proportion of patients whose physical status is poor.

Comment: There was no major change in criteria for ICU admissions and for institution of mechanical ventilation; and no development of additional ICU's, between the years stated.

come increasingly involved in acute care medicine,⁸⁹ the American Board of Anesthesiology included CCM in the definition of Anesthesiology, and the American Society of Anesthesiologists included CCM in its standards of practice.⁶ Resuscitation research, particularly when the brain is involved, may become anesthesiology's most important contribution to CCM in the future.

In spite of the increasing involvement of internists and pediatricians in intensive care, the involvement of anesthesiologists will continue to be desirable. The life-support-related wisdom and skills gained in the operating room go beyond the ability to intubate the trachea, and, conversely, the experience an anesthesiologist acquires outside the operating room renders him more effective in the anesthetic management of patients in poor physical status. It will become increasingly feasible for anesthesiologists to work at least part time as consultants outside the operating room, with the acceptance of non-physician helpers, and the trend toward reduction of unnecessary operations and improved operating room utilization.^{18,23,30,33,39}

Intensive Care Unit Organization

Grouping of patients in hospitals according to the intensity of care they require, *i.e.*, progressive patient care organization, is not new,⁵⁶ although the entire concept has not become popular, as it conflicts with the traditional department-specialty-organ orientation of hospital care. ICU's have evolved from post-anesthetic and -surgical recovery rooms,⁸¹ the Scandinavian respiratory ICU's of the early 1950's,^{25,46} and subsequently from different types of ICU's in various countries.^{10,24,29,34,45,51,79,83,102,108,114,117} About 1958, in the United States, a multidisciplinary (medical/surgical) ICU with 24-hour coverage by anesthesiologists was initiated at Baltimore City Hospitals.^{83,84} The life-saving potential of arrhythmia control and cardiopulmonary resuscitation (CPR) resulted in the establish-

ment of cardiac care units (CCU's) in most general hospitals in the United States in the 1960's.^{2,26,58,104} Other special ICU's evolved according to discipline (surgical, medical, pediatric), organ system (respiratory, cardiac, renal, neurologic-neurosurgical, hepatic, gastrointestinal), and clinical problem (trauma/shock)^{7,10,48,51,73,76,102,111}

TYPES OF ICU'S

The numbers and types of ICU's needed vary with types and sizes of hospitals and the kinds of patients admitted. The ICU's that actually evolve are also influenced by the power structure of each hospital's medical establishment. Concentrating critically ill but potentially salvageable patients who have multiple-organ failure in interdisciplinary ICU's or CCM centers (*e.g.*, combinations of adjacent medical, surgical, and cardiac ICU's)^{52,114,115} has both patient care and economic advantages over purely department-specialty-organ-oriented ICU's.^{48,92,94,108} In separate medical and surgical ICU's in university hospitals, the "department-owned" ICU physician is more likely to obtain primary patient care responsibility. In contrast, the general ICU approach is supported by the assumption that most critically ill or injured patients have multiple-organ failure, and will benefit from being seen by physicians of various specialties. However, there must be effective team coordination by a physician who is present and has the authority to act.

Published mortality data support the creation of ICU's and their staffing with specially trained nurses and full-time ICU physicians (table 2).^{48,69,80,92} Mortality data supporting multidisciplinary over departmental ICU's are scarce. In one university hospital, when specialty ICU's were replaced with a single multidisciplinary ICU (both staffed by physician specialists), mortality from respiratory insufficiency decreased from 30 to 10 per cent, and mortality from myocardial infarction from 30 to 15 per cent.⁴⁹

Obviously, neonatal ICU's, burn units, and spinal-cord-injury centers are examples of justifiable special ICU's to be established on a regional basis. For economic reasons, most community hospitals have developed general ICU's, which include CCU beds. In many university hospitals, the wishes of some department and division chairmen to have "their own units" have led to continued fragmentation of ICU's, increased costs, and difficulty in staffing. The need for more than one 6-8-bed ICU cluster (the recommended number of beds to be served by one nursing station) should be met not by fragmentation and multiplication of ICU's, but by grouping several such clusters into a CCM center.^{52,115}

REGIONALIZATION

ICU staffing and equipment largely determine the hospital's category of ECCM capability.^{5,14,41,88,120} A study of general ICU facilities in western Pennsylvania led to proposed criteria for four types of ICU's⁴¹ for hospital Categories I through IV⁵ (table 3). Type I ICU's should be established on regional bases, usually in Category I hospitals, *i.e.*, large comprehensive regional teaching hospitals. Ideally, they should have 24-hour in-ICU CCM physician coverage. Type II ICU's with in-house (not in-ICU) full-time physician coverage by at least senior residents are usually needed in Category II hospitals, *i.e.*, other major teaching and community hospitals. Type III ICU's, *i.e.*, intensive care by expertly trained nurses and respiratory therapists with strong ICU medical direction, on call at home, are common in Category III hospitals, which do not have house staff. Category III hospitals *can* provide safe basic intensive care, provided there is a rational referral policy for selected problem cases.³³ Category IV hospitals have no ICU's, but should be prepared for patient transfer with life support. Elective surgical procedures utilizing general anesthesia should be performed only in hospitals that have ICU's, and major definitive emergency surgery should ideally be done only in hospitals with type I or II ICU's.

No reliable methods are available to determine the needs for ICU beds. Estimates vary between 3 and 25 per cent of hospital beds, with an average of 12 per cent for major adult general hospitals (3 per cent for cardiac cases, 5 per cent for respiratory cases, and 4 per cent for others).^{114,115} We found western Pennsylvania to have 13 general ICU beds per 100,000 population, with an average annual total hospital admission rate of 140 per 100,000 population; an ICU admission rate of 5 per cent of hospital admissions; an average ICU stay of five days and a desirable ICU occupancy of 75 per cent.⁴¹ These ICU beds include cardiac care beds in community hospitals, but not in

teaching hospitals, which have separate CCU's. These data reflect *demand* of the medical community, not necessarily patient care needs.

ICU POLICIES AND PHYSICIAN STAFFING

New ICU's should be developed in an orderly fashion^{85,92,105}; first, a multidisciplinary, multiprofessional planning committee should determine the intensive care needs of the community and hospital, then identify candidates for ICU medical directorship and head nurse, and with their input, determine location and design of the ICU. This committee must agree on responsibilities, and finally, through the responsible authorities, appoint the ICU medical director, head nurse, and standing ICU committee. ICU medical directors should—ideally prior to opening the unit—see to it that trained physicians and non-physicians required for 24-hour coverage are available. They should establish standards and methods for quality control of life-support measures, record keeping, and education of physicians (see below) and non-physicians.^{1,30,39,83}

The various ICU policies and guidelines to be initiated by the ICU medical director and approved by the ICU committee should include infection control,⁴² procedures for brain death determination and certification,^{12,40,44,113} and discontinuance of extraordinary means of medical care when appropriate.^{8,57,75,78,112}

The smooth, safe functioning of an ICU depends on availability of motivated personnel with competence in CCM; on organization; on well-defined responsibilities and authorities; on standardization of certain procedures⁷⁵; and on the leadership of medical director and head nurse, required by national standards.^{22,105}

The authors' experience^{83,85,92} and national guidelines^{105,108} recommend that the ICU medical director should be chosen on the basis of experience, competence, interest, and availability, rather than specialty affiliation. He should have completed residency training in his clinical specialty and have acquired advanced skills and knowledge in life-support techniques. He or his designate should not merely be an administrative figurehead, but should approve all admissions and discharges, and be responsible at least for monitoring, resuscitation, and life support, and for ensuring that patient care involving multiple services is coordinated. In addition, he and his team should have total patient care responsibility in selected cases when required for titrated life support.

The ICU director must have at least one full- or part-time associate director (depending on the workload) to provide the presence of a staff physician in

TABLE 3. Categorization of Hospital Critical Care Facilities*

	Staffing				Emergency Life Support		Intensive Care			Definitive Therapy		Surgical Operations							
	In-house		On Call, Available		Basic	Ad- vanced	INC	IMC Base	IMC Ad- vanced	Basic Spec.	All Spec.	Emergency Resuscitative Surgery		PS 1-2		PS 3-5			
	ED	Hos- pital	<20 Min.	>20 Min.								Minor	Major	Minor	Major				
Category I Comprehensive emergency medical center	RN I S	A I S	All spec. & sub- spec.		X	X	X	X	X	X	X	X	X	X	X	X			
Category II Major emergency hospital	RN G	RNA I S	Most spec. incl. A	All spec.	X	X	X	X	X	X	X	X	X	X	X	X			
Category III Basic emergency hospital	RN G	RNA I S	A I S	Most spec.	X	X	X	X	X	X	X	X	X	X	X	X			
Category IV Resuscitation and minor emergency facility	RN	RN (G)	(G)	G	X														

* Abbreviations:
 ED = emergency department
 INC = intensive nursing care
 IMC = intensive medical care, with MD's and RN's in ICU
 RN = nurse
 I = internist/cardiologist and/or pediatrician
 S = surgeon
 A = anesthesiologist
 RNA = nurse anesthetist
 G = physician generalist, experienced in all phases of CPR; tracheal intubation, cricothyrotomy and tracheotomy; arrhythmia recognition and control; pericardial, pleural, gastric and bladder drainage; control of external hemorrhage; venous cutdown and arterial puncture; control of convulsions, and, if a teaching hospital, emergency management of intoxications
 Spec. = specialties
 Basic Spec. = anesthesiology, surgery, medicine, pediatrics
 PS 1-5 = physical status of patients from 1 (healthy) to 5 (moribund) as classified by American Society of Anesthesiologists.
 From Safar P, Grenvik A: Current concepts in grading emergency medical systems. CPR News and Reviews. Dallas, American Heart Association 4: 1-3, 1971.

the ICU, at least during the day hours, and for night and weekend consultation coverage. Additional block-assigned house staff or staff physicians trained (or in training) in intensive care must be provided to share 24-hour in-ICU patient care in Type I ICU's (only in-house coverage in Type II ICU's). It is feasible for community hospitals without house staff to qualify for Type II ICU's: anesthesiologists and ED physicians with additional training in CCM can provide ICU staffing, available in-house around the clock.

Those physicians of various base specialty backgrounds who have been dedicated for one or two decades to the initiation and modernization of titrated life support have encountered *frustrations* and *obstacles* to good patient care and teaching: 1) The lack of appreciation by many physicians of the difference between "titrated patient management" required for critical care, and the standard management "by rounding and prescription." 2) The "inverse hierarchy principle," *i.e.*, the tendency in some university hospitals to delegate the management of the critically ill to inexperienced junior house staff, with experienced staff removed from direct patient management; this perpetuates mediocrity, as it leads to "trial by error" and deprives house officers of patient management models. 3) The insistence of admitting physicians and surgeons to remain in charge of the patient's general care in the ICU, without being available to stay with him. 4) Fragmentation of care when numerous specialty consultants and team members function without coordination. 5) Departmental territorialism, particularly in teaching hospitals, creating hostile environments for physicians' education. 6) The need to train simultaneously in the same setting residents of the traditional base specialties and CCM physicians. 7) The difficulty of introducing innovative care and clinical research with too limited patient care responsibility.

The following developments may help resolve these problems in the future: 1) National identification and certification of physicians with special competence in CCM, which has majority, but not unanimous support of the multidisciplinary SCCM, and support of some of the major clinical specialty boards. 2) Institutionally-sanctioned interdepartmental (not only interdisciplinary) ICU programs; although they must have their own budgets, they should be informal, "without walls" and collaborate with other acute care-related multidepartmental programs such as neurosciences, cardiac care, and emergency care. 3) A national health care policy and insurance, which is expected to make more patients in need of hospital care select hospital teams rather than primary physicians.

The need for titrated management, which ICU physicians should learn in the physiology laboratory and in anesthesiology operating room activities, makes it unfeasible for the primary admitting physician to retain charge of total care and thus assume the coordinator role, while being unable to stay with his patient. Delegating primary care responsibility to other physicians of his admitting service, who likewise cannot stay with the patient and who do not know the details of the patient's case as well as the ICU physicians who are present, does not solve the problem. National guidelines^{105,106} suggest that the patient's personal admitting physician should delegate the role of team leader (coordinator) for the time of ICU stay, if he is not personally available at all times for team guidance. He should, however, always remain a member of the team to insure continuity.

Primary care responsibility of ICU physicians for all patients, as a policy, has not been "permitted" to occur in most general ICU's of teaching hospitals in the United States. However, such primary patient care responsibility does work well in many ICU's in Canada and overseas.^{24,45,59,108}

ICU physicians and their block-assigned house staff may have one or a combination of the following degrees of patient care responsibility: 1) *primary physician or team coordinator*—should have authority to resolve disputes, but should not be a dictator; 2) *automatic team member*—in charge of certain aspects of patient care, such as resuscitation, monitoring, respiratory care, and other life support measures; 3) *consultant*—becomes involved only when called.

The extent of ICU physician authority over patient care depends greatly on the personalities involved in each local setting; and has often become a compromise between the primary physician's commitment to "continuity of care" and the ICU physician's commitment to "titrated care." In community hospitals in the United States, where most patient care is happening, focusing on what is best for the patient's outcome is increasingly resolving the above dilemma, in general according to SCCM guidelines.¹⁰⁵ In university hospitals, patient care goals, however, sometimes continue to conflict with those of "teaching," and there are frequent rivalries between departmental and division chairmen and their house staffs over who controls the care of ICU patients.

Critical Care Medicine Physician Education

EDUCATIONAL PHILOSOPHY

The mere grouping of critically ill patients in an ICU does not assure a favorable outcome for them.

TABLE 1. Suggested Body of Knowledge in Critical Care Medicine, Table of Contents*

1. Pathophysiology and pharmacology
2. Emergency resuscitation
3. Prehospital emergency care
 - a. Training of paramedics
 - b. Field management of life-threatening emergencies
 - c. Medical command by radio and telemetry
 - d. Mobile ICU design and equipment
 - e. Others
4. Intrahospital intensive care
 - a. *Monitoring.* Invasive and non-invasive. Continuous and intermittent. Pulmonary, circulatory, renal, cerebral, and other variables.
 - b. *Mechanical ventilation and other respiratory therapy.* Optimal ventilation patterns. Blood gas control. Bronchoscopy, chest physiotherapy, etc.
 - c. *Circulatory support.* Arrhythmia recognition and control, including defibrillation, cardioversion, pacemaker use. Treatment of shock states. Pre- and afterload management. Assisted circulation techniques, etc.
 - d. *CNS management.* Coma evaluation. Electroencephalography. Intracranial pressure monitoring. Brain resuscitation (pharmacologic, physiologic, etc.). Brain death evaluation and certification. Vegetative states. Spinal cord failure.
 - e. *Renal support.* Peritoneal versus hemodialysis. Electrolyte-fluid-acid-base balance.
 - f. *Management of metabolism.* Metabolic derangements. Tube feeding. Total parenteral nutrition. Endocrine crises.
 - g. *Infection control.*
5. Educational methods, materials, evaluation
6. Organization
 - a. ICU design and management
 - b. ECCM regional systems
 - c. Health care evaluation
 - d. Economics
7. Miscellaneous
 - a. Anesthesiology (for non-anesthesiologist CCM physicians)
 - b. Bioengineering
 - c. Humanities, social sciences
8. Pediatric CCM

All above, with consideration of perinatology, infancy, and childhood

* Detailed knowledge and skill objectives for CCM educational programs for medical students, residents and fellows are available from the authors.

What does make the difference is the presence in such a unit of trained personnel, particularly critical care physicians, nurses, and technologists. Published data from coronary care units,^{2,26,58,104} units for critically ill newborns,¹¹¹ respiratory intensive care units,^{69,80} and general adult and pediatric ICU's^{18,92} have all demonstrated a significant reduction in mortality when such units are staffed around the clock by specially trained physicians (table 2).

The critical care physician adds several features:

- 1) He is *there*, remaining at the patient's bedside during hours of watching and recording observations, to detect changes in the patient's status and to intervene before easily managed problems become perhaps irreversible catastrophes, *i.e.*, "titrated management."
- 2) He is oriented to the whole patient, and thus can orchestrate collaboration among the many specialists who separately defend individual organ systems.
- 3) He can maintain quality control of life-support equipment, techniques, personnel, policies, and standing orders through his role as administrative and educational leader of the unit.
- 4) He can transfer emergency and long-term resuscitation expertise and education to the entire ECCM system (table 1), thus placing the ICU in perspective.

There is, then, a clear need for a new breed of

physician, even if some traditional specialists are correct in claiming that they have the expertise to *manage* critically ill patients without receiving further training in CCM.

First of all, the CCM physician must be a *generalist*, at least in the sense that his training and expertise cut across traditional specialty boundaries. He must have expertise in emergency resuscitation, respiratory care, and treatment of shock states; must understand pathophysiology and pharmacology; must be familiar with many areas of bioengineering in order wisely to utilize the tools that enable him to translate the language of the organism into algorithms and equations. However, these life-support specialists cannot do the job alone, since no-one can be an expert in all medical fields. Thus, he must be a *team member* or a *team leader*, able to work effectively with those whose areas of knowledge complement his own. Further, he must be *action-oriented*, capable of making rapid decisions and carrying out appropriate interventions with skill and perfection at the appropriate times, often within seconds. He must be a *diplomat*, capable of conducting tactful negotiations while serving as an advocate for the whole patient. He must be a person of *compassion*, able to see the human being behind all the equipment employed. He should have

a sense of the *community* and of his role in upgrading CCM beyond the confines of his ICU.

If we are to *train* CCM physicians, we must have specific, detailed, complete objectives—accomplishment of which will define the subspecialist in critical care (table 4). The design of any training program requires at least two interrelated steps: 1) the development of objectives, and 2) the development of the training program itself and methods for its evaluation (table 5).

The *objectives* of the program must be stated in terms of what skills, knowledge, and experiences (upon which judgement is based) the graduate must possess to be considered a CCM physician. These objectives must be derived from a task analysis of a CCM physician, *i.e.*, how he must perform in his daily work. Physicians carrying out critical care vary widely in their roles and responsibilities. In a large university center, the CCM physician may function primarily in consulting and coordinating roles, while the primary care of the patient is still largely the responsibility of admitting house staff and attending physicians. On the other hand, in a community hospital, the CCM physician may himself often be asked to assume primary care responsibility. Thus, the CCM physician must have the knowledge and skills required for all three—a) primary intensive care, b) intensive care team membership, and c) leadership. There is not yet any comprehensive work published in English on the whole field of CCM. An agreed-upon definition and identifiable "body of knowledge" of CCM, as requested by the American Board of Medical Specialties for subspecialty status, are now being developed by the SCCM. It is questionable, however, whether any specialty or subspecialty can claim its "distinct body of knowledge," since all represent overlapping components of "pathophysiology and therapeutics."⁹²

Educational objectives must be designed accordingly and must define the desired end product in measurable terms. Thus, a CCM physician is one who has achieved the specified competencies and acquired the specified knowledge. The emphasis here is on the achievement of skills and knowledge, not on the time or route taken to reach that end. The objectives are not sacrosanct, but should be subject to periodic review in terms of their feasibility and relevance.

The *training program* must be developed according to the objectives. Likewise, *testing methods* must be developed to determine whether the objectives have been achieved. Item by item, teaching and testing should undergo periodic revisions, until results are optimal, as each process reveals deficiencies in the other. New educational programs of this sort may

TABLE 5. Steps in Educational Program Development

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- I. Analyze *tasks* of trainee after graduation
 - A. Define tasks to be performed
 1. Skills performed
 2. Typical responsibilities
 - B. Analyze tasks
 1. Determine importance of each task
 - a. Number of times performed
 - b. Significance to patient care
 2. Identify knowledge required to perform tasks
 3. Identify critical errors
 4. Survey alternative methods for performing tasks
 5. Identify necessary equipment
 - C. Arrange tasks in logical sequence.
 1. By common prerequisites of requirements for performance, or
 2. By tasks performed together (*e.g.*, the tasks of CPR-ABCD)
 - II. Define *objectives*
 - A. Based on task analysis
 - B. Objectives should:
 1. Define a measureable activity
 2. Identify criteria for completion
 3. List conditions for successful performance
 - III. Develop and implement *course* (content, curriculum, experiences)
 - A. Based on objectives
 - B. Appropriate strategies (*e.g.*, skill teaching should include demonstrations and hands-on practice)
 - IV. Develop and implement *Evaluation*
 - A. Evaluation of students
 1. Knowledge examinations
 2. Skill testing
 3. Clinical observation of trainee performance.
 - B. Evaluation of the course, based on trainee evaluation, leads to:
 1. Modification of objectives
 2. Modification of course content
 3. Modification of teaching strategies
 4. Modification of evaluation mechanisms
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benefit considerably from active collaboration between teaching faculty and an educational research specialist. The latter can contribute ways and means which, although sometimes bewildering, have already provided significant objective improvement in the educational processes of other fields, and have helped in the development of self-training materials.

The cornerstone of a good educational program is a good *teaching staff*, comprising knowledgeable clinicians and scientists who bring to their work an enthusiasm and commitment the student can emulate. All education begins with imitation. Of necessity, this means that those involved in teaching critical care must personally examine, manipulate, and treat patients; not only round and lecture. Ideally, learning time and accumulation of clinical experiences should be individualized. However, the integration between learning and rendering service necessitates some uniformity of clinical rotation periods.

The *testing* of trainees, and thereby the programs, may include multiple-choice written knowledge tests

TABLE 6. Emergency and Critical Care Medicine Personnel Performance Objectives*

	Lay Public	EMT	Med. Student First Year; R.N.	Para- medic	ICU R.N.	Med. Student last Year	MD with EM Competence	Hospital M.D.	M.D. with CCM Competence
1. Basic life support (CPR-ABC) ^{1,37,95}	X	X	X	X	X	X	X	X	X
2. Basic emergency care, <i>i.e.</i> , 1 plus EMT's objectives ^{37, 65, 95}		X	(X)	X		X	X		(X)
3. Advanced life support (CPR-ABCD) ^{1,37,95}			(X)	X	X	X	X	X	X
4. Advanced emergency care, <i>i.e.</i> , 3 plus paramedics' objectives ^{20,37,66,85}				X		(X)	X		(X)
5. Basic intensive medical care (table 3)					(X)	(X)	(X)	(X)	X
6. Advanced intensive medical care (table 3)									X

* X = required; (X) = optional.

in which individual questions are derived from specific objectives, and skill tests on patients or manikins, simulating patient conditions, using checklists to assess the students' performance in detail.

Critical care physicians share many skills with other personnel (table 6). Thus, education in critical care could be viewed as a pyramid, with lay persons and allied health professionals representing the greater number of first responders (the base of the pyramid). It continues through nurses', medical students', and various specialty residents' training, and culminates in CCM fellowship training (the tip of the pyramid). The depths of training required—least for the lay person and most for the CCM physician—could be illustrated as an inverted pyramid within the upright manpower pyramid.

To the best of our knowledge, there is no published description of any CCM physician training program other than that at the University of Pittsburgh.^{95,92,94} Therefore, it may be of value to present the authors' experience with three levels of CCM physician education.

MEDICAL STUDENTS

By the early 1960's it became clear that education of medical students in the pathophysiology of acute life-threatening states, as well as resuscitation and long-term life support, was essentially lacking. National surveys subsequently revealed that approximately 50 per cent of physicians nationwide considered themselves incapable of carrying out effective CPR, and 20 per cent of medical schools questioned the abilities of their senior students in this area.^{95,100} For this reason, an educational program for medical students in "emergency and critical care medicine" was designed. In its present form, the program spans four years and draws from a multidisciplinary teaching faculty.

First-year medical students are offered a 30-hour elective course in emergency medical care.²¹ The objectives of the first part of this course are the knowledge and skills required to pass the state EMT I examination, and the American Heart Association's basic rescuer's test in CPR. The second portion of the course, given in conjunction with the student's physiology program, comprises seminars on the pathophysiology of acute dying processes and their reversibility.

Second-year students, at the beginning of their core clinical clerkship, undergo a full day of obligatory training in CPR with manikin drill to perfection in the ABC's of CPR.⁹⁵ In addition, they receive an introduction to CPR advanced life support. Also, recognition of respiratory failure is taught as part of the "Introduction to Medicine" course.

Third-year medical students receive an obligatory three-week clerkship in anesthesiology and CCM, the backbone of the critical care experience. The general objectives of this clerkship include: acquisition of basic life-support skills, using manikins in a self-training laboratory and patients in the operating and recovery rooms; appreciation of the difference between "titrated management," required in critical care, and "management by rounding and prescription," customarily used in general ward care; recognition of the need to suspect immediately and treat swiftly respiratory, circulatory, and cerebral failure; and recognition of the need to learn life-saving techniques to perfection. In groups of 5–15, they attend one week of all-day, highly structured seminars, the content of which is kept uniform through the use of syllabus materials. The clerkship is concluded with two weeks of patient practice in the operating and recovery rooms. Skill-acquisition lists are used to assess the students' performances in detail, and their knowledge is tested and graded at the end of this clerkship.

Fourth-year medical students are offered a variety of six-week electives. Interested students may gain further experience in caring for patients in the operating room during anesthesia, in ICU's, in ED's, and in mobile ICU-type ambulances. A research elective in anesthesiology and critical care is also offered.

RESIDENTS

At the next level of training, we encounter the house officers in anesthesiology, internal medicine, pediatrics, and surgery, who are not destined to become critical care physicians. Nonetheless, they will, in the course of their careers, be dealing with critically ill patients, and may be called upon to participate as part of a multidisciplinary team serving an ICU. For these reasons, it is desirable that residents in anesthesiology, surgery, and primary care specialties obtain firsthand guided experience in critical care. We believe that this can be accomplished by short-term block rotations through an ICU, where they are trained as team members under the guidance of CCM staff and fellows. At this time, ICU rotation is mandatory for residents in anesthesiology and voluntary for those of medicine, pediatrics, and surgery. They spend 1-3 months in one of the four general ICU's of the Health Center.

CRITICAL CARE MEDICINE FELLOWS

A CCM fellowship program was begun in 1963 as a third (optional) year of the Anesthesiology residency.^{85,92} Today, however, the CCM fellows represent all five major disciplines mentioned above (table 7). Candidates must have at least three years of residency in their base specialties before they are admitted to this 1-2-year program. The first of these years in CCM is clinically oriented. Individualized basic experience is gained in one or more of the four general ICU's in the Health Center,^{48,52,92} three for adults, and one for pediatric patients, encompassing more than 50 beds and 3,000 admissions per year. The ten full-time CCM staff physicians, including the ICU directors, have been selected to represent the major specialties involved in critical care.

The program is flexible in order to meet the needs of physicians of different specialty backgrounds. Selective rotations are available through cardiology/CCU, nephrology/renal dialysis unit, neonatal ICU, neurosciences, operating room anesthesia, bioengineering, and the emergency department (for prehospital care experience, including physician command of paramedics). In addition to more or less continuous bedside instruction, there are daily ICU teaching rounds, x-ray demonstrations, case

TABLE 7. CCM Physician Fellowships, University Health Center of Pittsburgh, Results in 14 years (7/1963-6/1977)

	Fellows	
	Number	Per Cent
A. 113 fellows <i>trained</i> —6-24 months		
Anesthesiologists	69	
Internists	25	
Pediatricians	11	
Surgeons	6	
Emergency physicians	2	
	113	
B. 92 fellows <i>followed up</i> (1976)		
1. Involvement		
Full-time CCM	43	47
Part-time CCM	49	53
	92	100
2. Institutions (hospitals)		
University or university-affiliated	64	70
Non-university-affiliated	28	30
	92	100
3. Locations		
United States	64	70
Non-United States (all continents)	28	30
	92	100

discussions and seminars, weekly CCM conferences, and an annual symposium. Teaching topics include all aspects of ICU patient management, organization, administration, budgeting, data collection, evaluation, and leadership. Further, EMS standards, planning, organization, communication, and evaluation matters are discussed, as well as design of research protocols, investigational techniques, statistics, and writing of manuscripts for presentation and publication of papers on performed research work.

The fellows are obligatory team members, responsible for respiratory care and life support in the ICU, as well as for hospital-wide resuscitations. They obtain experience in advanced invasive and non-invasive monitoring, respiratory care, and other life-support techniques, and are exposed to different special care units in several hospitals, where they may fulfill different roles (primary physician/team leader/team member/consultant). While daily rounds and conferences contribute in large measure to their education, the fellows' personal management of the critically ill and injured patients is the most important component of their training.

In addition, one-year fellows are encouraged to participate in clinical research and an optional second year is available for full-time laboratory, clinical, or health care delivery research as part of the Resuscitation Research Institute of the University.

Graduates of such programs have ample job op-

portunities, although many are not without frustrations. A follow-up of the first 92 graduates of the CCM physician training program in Pittsburgh shows that about half of them remained in full-time CCM work, and no-one has indicated that he or she has left CCM completely (table 7).

NATIONAL TRENDS

The Society of Critical Care Medicine, in cooperation with specialty boards and with the National Board of Medical Specialties, is in the process of developing a CCM fellowship inspection mechanism, and an examination toward "certification of special competence in CCM," as substitute for a conjoint subspecialty Board.⁶¹

The manpower needs in CCM, however, are still unmet. As mentioned above, it is estimated that at least 2,800 full-time CCM staff physicians are needed in this country. If we are to approach this figure in the next ten years, we must produce at least 200–300 CCM physicians per year, a figure far beyond the output of the existing 26 programs, with a total number of 72 fellowship positions reported by the SCCM. Of these 26 programs, 11 are administratively under anesthesiology departments, six under departments of medicine, pediatrics, or surgery, and nine are multidisciplinary. Eighteen of these 26 programs conform to SCCM guidelines, and more than one ICU is involved in more than half of them. Clinical research is available in all these programs.

Clearly, we must either considerably expand existing programs and establish new ones, or consider alternate routes for the training of CCM physicians. In this regard, we are really not fundamentally concerned with where a CCM physician acquires his capabilities, how long it takes, or what learning methods he employs, but rather with whether he has achieved a defined set of skill and knowledge objectives at the end of his training. This might be possible through modification of existing residency programs in anesthesiology and other major clinical disciplines, which must include a truly multidisciplinary multidepartmental faculty.

Conclusions

The goal of critical care medicine is to improve care for acute life-threatening illnesses and injuries, leading to increased salvage of life with human mentation. Recent advances in the knowledge and technology of acute care still await application through regional emergency and critical care medicine systems, all components of which must be upgraded and coordinated. Close cooperation among physicians com-

mitted to emergency care and intensive care at the hospital level and for community-wide organization of care is essential. The trend for critical care medicine to become a subspecialty of anesthesiology, medicine, pediatrics, or surgery is viable. There is no general agreement at this time concerning the definition and scope of critical care medicine. Combined emergency care and critical care education by interdisciplinary programs should be upgraded for medical students and residents in all clinical disciplines. CCM fellowship training programs should be expanded to meet manpower needs for ICU leadership, to improve standards in all components of the emergency and critical care medicine system, and to foster acute care-related research. All anesthesiologists should be educated to the capability of functioning as consultants in resuscitation and respiratory intensive care. Their full- or most-time involvement as leaders or team members in critical care medicine will depend on the individual's competence, interest, availability, and financial considerations.

The authors thank Dr. Nancy Caroline for invaluable help with the writing and editing of the manuscript. She, Mr. James McClintock, and past and present Critical Care Medicine staff and fellows of the University of Pittsburgh made many valuable suggestions that were incorporated into the paper.

References

1. American Association of Critical Care Nurses: Recommended course content for use in development of critical care nursing curricula. *Heart Lung, J Crit Care* 1:317–323, 1972
2. American Heart Association: Coronary care unit (1) and (2). A specialized intensive care unit for acute myocardial infarction. *Mod Concepts Cardiovasc Dis* 34:23–26; 34:27–30, 1965
3. American Heart Association: Emergency Resuscitation Team Manual: A Hospital Plan (EM 439). New York, American Heart Association, 1968
4. American Heart Association and National Research Council: (a) Standards for cardiopulmonary resuscitation and emergency cardiac care. *JAMA suppl* 227/7:833–868, 1974. (b) Proceedings of the National Conference on Standards for Cardiopulmonary Resuscitation and Emergency Cardiac Care, May 1973. American Heart Association, Dallas, TX 75231, 1975
5. American Medical Association: Categorization of Hospital Emergency Capabilities. Chicago, American Medical Association, 1971
6. American Society of Anesthesiologists: Minimal and Optimal Standards for Anesthesiology Services. Park Ridge, Ill., American Society of Anesthesiologists, 1973
7. Bachman L, Downes JJ, Richards CC, et al: Organization and function of an intensive care unit in a children's hospital. *Anesth Analg (Cleve)* 46:570–574, 1967
8. Baier K: The ethics of passive euthanasia. *Crit Care Med* 4:317–319, 1976
9. Bailey GL (editor): Hemodialysis, Principles and Practices. New York, London, Academic Press, 1972

10. Bates DV: Organization of intensive care units: Results in cases of respiratory failure. *ANESTHESIOLOGY* 25:199-202, 1964
11. Beck GS, Leighninger DS: Death after a clean bill of health. So-called "fatal" heart attacks and treatment with resuscitation techniques. *JAMA* 174:133-135, 1960
12. Beecher HK: A definition of irreversible coma, Report of the Ad Hoc Committee of the Harvard Medical School to examine the definition of brain death. *JAMA* 205:337-340, 1968
13. Bendixen HH, Egbert LD, Hedley-Whyte J, et al: Respiratory Care. St. Louis, C. V. Mosby, 1965
14. Benson DM, Safar P: Categorization and regionalization of hospital emergency facilities, Public Health Aspects of Critical Care Medicine and Anesthesiology. Edited by Safar P. Philadelphia, F.A. Davis, 1974, pp 137-159
15. Benson DM, Stewart C: Inadequacy of prehospital emergency care. *Crit Care Med* 1:130-134, 1973
16. Berkebile P, Benson DM, Ersoz CJ, et al: (a) *Crit Care Med* 1:115-116, 1973 (abstr); (b) Public education in CPR: Evaluation of three self-training methods. Proceedings of the AHA/NRC CPR/ECC Conference May 1973, Dallas TX, American Heart Association, 1975, pp 13-23
17. Boyd DR: A symposium on The Illinois Trauma Program: A systems approach to the care of the critically injured. Introduction: A controlled systems approach to trauma patient care. *J Trauma* 13:275-276, 1973
18. Bunker JP: Surgical and anesthesia workloads in the United States, Public Health Aspects of Critical Care Medicine and Anesthesiology. Edited by Safar P. Philadelphia, F.A. Davis, 1974, pp 205-217
19. Caroline NL: Medical care in the streets. *JAMA* 237:43-46, 1977
20. Caroline NL, McClintock J: Advanced training program for emergency medical technicians (paramedics)—National Standards Course Guide: Instructor lesson plan; Textbook. 1976. Available from Department of Transportation, Washington, D. C. 20402; and U. S. Government Printing Office, 1977
21. Caroline NL, Safar P: Introduction to Emergency Medicine. Syllabus for First Year Medical Students. Intramural publication. Available from Department of Anesthesiology/CCM, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania 15261, 1976
22. Carroll WW: Joint Commission on accreditation standards for anesthesia services and intensive care units, Public Health Aspects of Critical Care Medicine and Anesthesiology. Edited by Safar P. Philadelphia, F.A. Davis, 1974, pp 49-63
23. Carron H: Anesthesia manpower in the United States, Public Health Aspects of Critical Care Medicine and Anesthesiology. Edited by Safar P. Philadelphia, F. A. Davis, 1974, pp 245-264
24. Cherniack RM: Recognition and management of respiratory insufficiency. *ANESTHESIOLOGY* 25:209-216, 1964
25. Clemmesen C, Nilsson E: Therapeutic trends in the treatment of barbiturate poisoning. *Clin Pharmacol Ther* 2: 220-229, 1961
26. Corday E: Early care for the acute coronary suspect, Sixth Bethesda Conference. *Am J Cardiol* 23:603-618, 1969
27. Crampton RS, Aldridge RF, Stillerman R, et al: Prehospital CPR in acute myocardial infarction. *N Engl J Med* 286: 1320-1321, 1972
28. Cullen DJ, Ferrara LC, Briggs BA, et al: Survival, hospitalization charges and follow-up results in critically ill patients. *N Engl J Med* 294:982-987, 1976
29. Dammann JF, Wright DJ, Updike OL, et al: Assessment of continuous monitoring in the critically ill patient. *Dis Chest* 55:240-244, 1969
30. DeKornfeld TJ: Respiratory therapy services in the United States, Public Health Aspects of Critical Care Medicine and Anesthesiology. Edited by Safar P. Philadelphia, F. A. Davis, 1974, pp 193-204
31. Dripps RD: The anesthesia survey: Objective analysis of a medical specialty, Medical Education and Anesthesia. Edited by White JM. Philadelphia, F. A. Davis, 1966
32. Elam JO, Brown ES, Elder JD Jr: Artificial respiration by mouth-to-mask method: Study of respiratory gas exchange of paralyzed patients ventilated by operator's expired air. *N Engl J Med* 250:749-754, 1954
33. Ersoz CJ: Putting together a critical care team in your hospital. Critical care medicine (special section). *Med Opinion* 3/10: 44-51, 1974
34. Fairley HB: The Toronto General Hospital respiratory unit. *Anaesthesia* 16:267-274, 1961
35. Farrington JD: Death in a ditch. *Bull Am Coll Surg* 52: 121-130, 1967
36. Fitts WT, Lehr HB, Bitner RL, et al: An analysis of 950 fatal injuries. *Surgery* 56:663-668, 1964
37. Frey R (chairman): International Symposium on Mobile Intensive Care and Emergency Medical Services Systems. Mainz, Gutenberg University, 1973. Recommendations. *J Am Coll Emergency Physicians* 4:60-66, 1975
38. German Society of Anesthesiology and Resuscitation: Recommendations for physician involvement in pre-hospital emergency care. *Anaesthetist* 22:245, 1973
39. Grenvik A: Role of allied health professionals in critical care medicine. *Crit Care Med* 2:6-10, 1974
40. Grenvik A: Determination of brain death, procurement of donor organs, discontinuance of efforts, Critical Care Medicine. Edited by Weil MH, Shubin H. New York, Kolen Publishers, 1974
41. Grenvik A (chairman): Guidelines for the planning and development of adult general intensive care in Western Pennsylvania. Regional task force on general ICUs of the Comprehensive Health Planning Association of Western Pennsylvania, Inc., December 1974
42. Grenvik A, Snyder J, Pazin G, et al: ICU policy and infection control literature. From author, Univ. Pittsburgh.
43. Gordon AS, Frye CW, Gittelsohn L, et al: Mouth-to-mouth versus manual artificial respiration for children and adults. *JAMA* 167:320-328, 1958
44. Harp JR: Criteria for the determination of death. *ANESTHESIOLOGY* 40:391-397, 1974
45. Holmdahl MH: Respiratory intensive care unit. *ANESTHESIOLOGY* 23:559-568, 1962
46. Ibsen B: The anesthetist's viewpoint on treatment of respiratory complications in poliomyelitis during the epidemic in Copenhagen, 1952. *Proc R Soc Med* 47:72-74, 1954
47. Jude JR, Elam JO: Fundamentals of Cardiopulmonary Resuscitation. Philadelphia, F. A. Davis, 1965
48. Kampschulte S, Safar P: Development of multidisciplinary pediatric intensive care unit. *Crit Care Med* 1:308-315, 1973
49. Kassebaum D (University of Oregon, Portland, Oregon): Personal communication, 1973 (quoted in ref. 94)
50. Kennedy R: Manual on Emergency Care, American College of Surgeons. Philadelphia, W. B. Saunders, 1966

51. Kinney JM: The intensive care unit. *Bull Am Coll Surg* 51:201-356, 1966
52. Kirimli B: Equipment selection (for ICUs). *Hospitals* 43:46-48, 1969
53. Kouwenhoven WB, Jude JR, Knickerbocker GG: Closed chest cardiac massage. *JAMA* 173:1064-1067, 1960
54. Lind B, Lund I (editors): *International Symposium on Emergency Resuscitation*. Oslo, Norway, 1967. *Acta Anaesthesiol Scand suppl* 29, 1968
55. Little DM Jr: There shall be no pain. *ANESTHESIOLOGY* 39:467-469, 1973
56. Lockward HJ, Giddings L, Thomas EJ: Progressive patient care. *JAMA* 172:132-137, 1960
57. Loughhead M, Leon M, Snyder JV, et al: ICU patient categorization. *Crit Care Med* 4:108-109, 1976
58. Lown B, Klein MD, Hershberg PI: Coronary and precoronary care. *Am J Med* 46:705-724, 1969
59. Lust P (University Hospital, Brussels, Belgium): Personal communication, 1976
60. Michenfelder JD, Gronert GA, Rehder K: Neuroanesthesia. *ANESTHESIOLOGY* 30:65-100, 1969
61. Myers JD: The concept of the conjoint specialty board. *JAMA* 218:1415-1416, 1971
62. Nagel EL, Hirschman JC, Nussenfeld SR, et al: Telemetry-medical command in coronary and other mobile emergency care systems. *JAMA* 214:332-338, 1970
63. National Academy of Sciences-National Research Council, American Heart Association: Ad hoc committee on cardiopulmonary resuscitation; statement on cardiopulmonary resuscitation techniques and training. *JAMA* 198:372-379, 1966
64. National Academy of Sciences-National Research Council: Medical requirements for ambulance design and equipment. Committee on Emergency Medical Services. Publication USGPO 0-381-725, September 1968
65. National Academy of Sciences-National Research Council: Training of ambulance personnel and others responsible for emergency care. Committee on Emergency Medical Services. Publication USGPO 0-381-726, March 1968
66. National Academy of Sciences-National Research Council: Advanced training program for emergency medical technicians—ambulance. Committee on Emergency Medical Services. September 1970
67. National Safety Council: *Accident Facts*. Chicago, National Safety Council, 1971, p 96
68. Nemoto EM, Bleyaert AL, Stezoski W, et al: Amelioration of post-ischemic-anoxic brain damage by thiopental. *Advances in Cardiopulmonary Resuscitation*. Edited by Safar P. New York, Springer Verlag, 1977
69. O'Donohue WJ, Baker JP, Bell GM, et al: The management of acute respiratory failure in a respiratory intensive care unit. *Chest* 58:603-610, 1970
70. Pantridge JF, Geddes JS: A mobile intensive care unit in the management of myocardial infarction. *Lancet* 2:271-273, 1967
71. Papper EM: A matter of definition. *ANESTHESIOLOGY* 28:969-972, 1967
72. Pennsylvania Medical Society, Commission on Emergency Medical Services: Emergency medical and health services in Pennsylvania. Present status, recommendations for improvement. *Pennsylvania Med* 74:3-38, 1971
73. Petty TL: Respiratory care is mod! *Chest* 59:475-476, 1971
74. Phillips OC, Capizzi LS: Anesthesia mortality, Public Health Aspects of Critical Care Medicine and Anesthesiology. Edited by Safar P. Philadelphia, F. A. Davis, 1974, pp 219-244
75. Pontoppidan H (chairman): Optimum care for hopelessly ill patients. A report to the Clinical Care Committee of the Massachusetts General Hospital. *N Engl J Med* 295:362-364, 1976
76. Pontoppidan H: Post-operative ventilatory support. *Anesth Analg (Cleve)* 41:773-775, 1962
77. Poulsen H (editor): *International Symposium on Emergency Resuscitation*. Stavanger, Norway, 1961. *Acta Anaesthesiol Scand suppl* 9, 1961
78. Rabkin MT, Gillerman G, Rice NR: Orders not to resuscitate. *N Engl J Med* 295:364-366, 1976
79. Robinson JS: The design and function of an intensive care unit. *Br J Anaesth* 38:132-142, 1966
80. Rogers RM, Weiler C, Ruppenthal B: Impact of the respiratory intensive care unit on survival of patients with acute respiratory failure. *Chest* 62:94-97, 1972
81. Sadove MS, Kretschmer HE, Wyant GM, et al: An ideal recovery room. *Mod Hosp* 76:88-96, 1951
82. Safar P, Escarraga L, Elam J: A comparison of the mouth-to-mouth and mouth-to-airway methods of artificial respiration with the chest-pressure arm-lift methods. *N Engl J Med* 258:671-677, 1958
83. Safar P, DeKornfeld T, Pearson J, et al: Intensive care unit. *Anaesthesia* 16:275-284, 1961
84. Safar P, Berman B, Diamond E, et al: Cuffed tracheotomy tube versus tank respirator for prolonged artificial ventilation. *Arch Phys Med Rehab* 43:487-493, 1962
85. Safar P: The anesthesiologist as intensivist, *Science and Practice in Anesthesia*. Edited by Eckenhoff J. Philadelphia, J. B. Lippincott, 1965, pp 130-140
86. Safar P: Intensive care unit organization, *Respiratory Therapy*. Philadelphia, F. A. Davis, 1965, pp 361-374
87. Safar P, Brose R: Ambulance design and equipment for resuscitation. *Arch Surg* 90:343-348, 1965
88. Safar P (chairman): Community-wide emergency medical services. American Society of Anesthesiologists. Committee on Acute Medicine. *JAMA* 204:595-602, 1968
89. Safar P: *Cardiopulmonary Resuscitation; a Manual for Physicians and Paramedical Instructors (in twelve languages)*. First edition: World Federation Societies of Anesthesiologists, 1968; Second edition (*Cardiopulmonary-Cerebral Resuscitation*): Philadelphia, W. B. Saunders, 1978 (to be published)
90. Safar P, Esposito G, Benson DM: Ambulance design and equipment for mobile intensive care. *Arch Surg* 102:163-171, 1971
91. Safar P, Esposito G, Benson DM: Emergency medical technicians as allied health professionals. *Anesth Analg (Cleve)* 51:27-34, 1972
92. Safar P, Grenvik A: Critical care medicine, organizing and staffing intensive care units. *Chest* 59:535-547, 1971
93. Safar P (editor): Public health aspects of critical care medicine and anesthesiology, *Clinical Anesthesia*. Philadelphia, F. A. Davis, 1974, volume 10/3
94. Safar P, Benson DM, Esposito G, et al: Emergency and critical care medicine: Local implementation of national recommendations, *Public Health Aspects of Critical Care Medicine and Anesthesiology*. Edited by Safar P. Philadelphia, F. A. Davis, 1974, pp 65-125
95. Safar P, Benson DM, Berkebile P, et al: Teaching and organizing cardiopulmonary resuscitation, *Public Health Aspects of Critical Care Medicine and Anesthesiology*. Edited by Safar P. Philadelphia, F. A. Davis, 1974, pp 161-192
96. Safar P: Critical care medicine—Quo vadis? *Crit Care Med* 2:1-5, 1974

97. Safar P, Stezoski W, Nemoto EM: Amelioration of brain damage after 12 minutes cardiac arrest in dogs. *Arch Neurol* 33:91-95, 1976
98. Safar P, Elam J (editors): *Advances in Cardiopulmonary Resuscitation (The Wolf Creek Conference, October 1975)*. New York, Springer-Verlag, 1977
99. Sands PA: Political roadblocks to implementation of emergency medical services in Allegheny County. Master's thesis. University of Pittsburgh Graduate School of Public Health. Pittsburgh, Pennsylvania, July 1973
100. Seeley S: Accidental death and disability: The neglected disease of modern society. National Academy of Sciences-National Research Council, Washington, D. C., 1966
101. Shapiro HM: Intracranial hypertension: Therapeutic and anesthetic considerations. *ANESTHESIOLOGY* 43:445-471, 1975
102. Shoemaker WC, Elwyn DH, Rosen AL: Development and goals of a trauma and shock research center. *J Mt Sinai Hosp (NY)* 35:451-472, 1968
103. Shoemaker WC: Interdisciplinary medicine: Accommodation or integration? *Crit Care Med* 3:1-4, 1975
104. Shubin H, Weil MH: Cardiac surveillance and coronary care. *Mod Med* 39:114-119, 1971
105. Society of Critical Care Medicine: Guidelines for organization of critical care units. *JAMA* 222:1532-1535, 1972
106. Society of Critical Care Medicine: Guidelines for physician education in critical care medicine. *Crit Care Med* 1:39-42, 1973
107. Somers AR: Who's in charge here?—or Alice searches for a king in Mediland. *N Engl J Med* 287:849-855, 1972
108. Spence M: An organization for intensive care. *Med J Aust* 1:795-801, 1967
109. Stephenson HE: The teaching of emergency medical care in medical schools in the US and Canada. *Bull Am Coll Surg* 56:9-11, 1971
110. Storey PB, Roth RB: Emergency medical care in the Soviet Union. *JAMA* 217:588-592, 1971
111. Swyer PR: The regional organization of special care for the neonate. *Pediatr Clin North Am* 17:761-776, 1970
112. Tagge GF, Adler D, Bryan-Brown CW, et al: Relationship of therapy to prognosis in critically ill patients. *Crit Care Med* 2:61-63, 1974
113. Wecht CH: Determination of death. *Bull Allegheny Co Med Soc* 58:29-34, 1969
114. Weil MH: A new look at the critically ill. *Hosp Pract* 2:27-37, 1967
115. Weil MH, Shubin H: Symposium on care of the critically ill. *Mod Med* 39:83-137, 1971
116. Weil MH: The Society of Critical Care Medicine, its history and its destiny. *Crit Care Med* 1:1-4, 1973
117. Wiklund E: Design of the recovery room and ICU. *ANESTHESIOLOGY* 26:667-674, 1965
118. Williamson JW: Evaluating quality of patient care. A strategy relating outcome and process assessment. *JAMA* 218:564-569, 1971
119. Winchell SW, Safar P: Teaching and testing lay and paramedical personnel in cardiopulmonary resuscitation. *Anesth Analg (Cleve)* 45:441-449, 1966
120. Youmans RL, Brose RA: A basis for classifying hospital emergency services. *JAMA* 213:1647-1651, 1970