

# Critical care medicine

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**The treatment of acute, life-threatening disorders, usually in intensive care units.** Critical care medicine has been practiced informally for many decades in trauma centers, postanesthesia recovery rooms, coronary care units, delivery rooms, emergency rooms, and postoperative areas. The facilities and trained personnel available in the intensive care unit (ICU) permit extensive monitoring of physiological variables, organization of complex, multidisciplinary diagnostic and therapeutic plans, administration of therapy to predetermined goals, and expert nursing care.

Critical care thus runs counter to the traditional division of specialties by organ or organ system. Specialists in critical care undergo training beyond a primary qualification (internal medicine, surgery, anesthesia, or pediatrics), and must be able to manage acute respiratory, cardiovascular, metabolic, cerebral, and renal problems, as well as infections. The patients may be newborns, children, or adults suffering from trauma or acute life-threatening disease. Patients having failure of multiple organs, complicated medical problems, disorders falling into several medical specialties, or a need for 24-h care often become the responsibility of the critical care specialist.

The intensive care unit is the most labor-intensive, technically complex, and expensive part of hospital care. Of the average daily cost of a bed, about 70% is for personnel. The intensive care unit, however, may be crucial to the patient's survival.

## Historical background

Although there were probably precedents, it was during the Crimean War in 1856 that Florence Nightingale placed the most serious casualties nearest the nursing station for the sake of better and more efficient care. Operational efficiency became important in the deployment of scarce medical resources and personnel, particularly in combat. In the civilian area, a special room was used for the postoperative care of neurosurgical patients at Johns Hopkins Hospital in 1923. In 1930, a postanesthesia recovery room was installed at Tübingen, Germany, as well as a unit that applied new knowledge and techniques to postoperative needs. Casualty facilities and trauma hospitals were developed in Europe around World War II. Shock wards were established in field hospitals to resuscitate battle casualties before and after their operations; the importance of blood transfusions, early operation, and postoperative care were recognized. Subsequently, trauma units, coronary care units, and postoperative care were recognized. Trauma units, coronary care units, and neonatal intensive care units were established in the United States to promote expediency and efficiency. In community hospitals, the need for intensive care units was mainly the result of the shortage of nurses during and after World War II. It became essential to group patients according to the severity of their illness.

A historical example illustrates these developments. In the poliomyelitis epidemic of 1952 in Copenhagen, an estimated 5000

persons were afflicted; about 10% of these had respiratory paralysis from bulbar polio. Tubes placed through surgically prepared openings in the trachea and manual ventilation were instituted for patients with respiratory paralysis. To assist patients who could not breathe, medical teaching and research were suspended and the students worked day and night in shifts to ventilate patients by hand. This extraordinary effort reduced the mortality rate from 85 to 40%. This episode stimulated clinical research toward the development of positive-pressure mechanical ventilation. An early model of the Engstrom respirator proved to be reliable; through subsequent developments the iron lung, with its negative-pressure whole-body ventilation, was superseded. Mechanical ventilation was used for patients having crushed chest injuries and was employed during thoracic surgery and abdominal surgery. Respiratory and multidisciplinary intensive care units were rapidly developed for patients whose respiration was inadequate for any of various reasons.

Internists became involved in critical care when it was discovered that apparent death from heart attack could be treated by electric shock: dysrhythmias (abnormal heart rhythms) were found to be the most common cause of death from myocardial infarction in the first 12 h after the onset of symptoms. Resuscitation was found to be possible only if a well-equipped, trained team capable of inserting the tracheal tube and performing defibrillation arrived within minutes of cardiac arrest. This finding gave impetus to the development of paramedic transport of patients (prehospital emergency care) and in-hospital coronary care units.

In the late 1950s, modern emergency resuscitation developed. It was based on the observation that the expired breath of the rescuer could be used to breathe for the patient with ventilatory arrest. Mouth-to-mouth breathing and external cardiac massage led to the technique of cardiopulmonary resuscitation (CPR) and subsequently to protocols for basic life support and advanced life support.

The introduction of cardiac catheterization, its application to the diagnosis and management of congenital and acquired heart disease, and its later application to cardiovascular monitoring have been basic to managing circulatory problems in patients in the intensive care unit. The advent of plastic catheters facilitated such procedures as intravascular blood sampling, infusion of fluids and titration of drugs, and circulatory measurements. In the early 1970s, the flow-directed, balloon-tip pulmonary artery catheter was introduced, which in combination with a thermodilution system permits estimation of cardiac output.

Although renal failure had been managed with peritoneal dialysis beginning in 1923, hemodialysis (dialysis of blood through an external membranous coil) came into wide clinical use only after World War II. Today, in addition to being used in outpatient and other inpatient settings, hemodialysis is employed in intensive care units, for example, to treat patients who have multiple organ failure.

Many advances in medicine have increased the need for critical care. Among them are heart operations, transplantation of various organs, and cancer chemotherapy.

## ***Life-support systems***

Perhaps the single most useful function of the intensive care unit is to provide life-support systems for desperately ill patients who would not survive without them. Such systems are briefly discussed below.

### **Mechanical ventilation**

A mechanical ventilator automatically delivers oxygen-enriched air at positive pressure through an endotracheal tube. The machine may be driven by pressure (pressure-regulated) or volume (volume-regulated). Adjustments may be made to control rate of ventilation, maximum airway pressure, peak flow, ratio of time of inspiration to that of expiration, and oxygen concentration. Ventilator modes determine how much effort the patient makes and how much assistance the ventilator

provides; the ventilator can entirely control ventilation. Different clinical conditions require somewhat different ventilator modes.

## Cardiopulmonary resuscitation

Resuscitation for cardiopulmonary arrest must be begun at the site and time of arrest whether in the intensive care unit, elsewhere in the hospital, or in the community. Arrest may occur more frequently in the intensive care unit than elsewhere because the sickest patients are usually there. Out in the field, without equipment, cardiopulmonary resuscitation consists of (a) airway control (positioning of head, inflation of lungs, manual clearing of mouth and throat), (b) breathing support [mouth-to-mouth (or nose) ventilation], and (c) circulation support (control of external hemorrhage, mechanical chest compressions if the patient is pulseless, and circulatory support with intravenous fluids if available). When equipment is available, cardiopulmonary resuscitation consists of the above plus (a) pharyngeal suctioning, tracheal intubation, or, if this is not immediately successful, creation of an opening into the trachea in the neck; (b) ventilation manually (using a bag and mask) or mechanically, with oxygen added; and (c) mechanical chest compressions, or, if blood pressure and pulse do not respond immediately, open-chest massage with direct cardiac compressions.

Advanced life support consists of the use of cardiac drugs, fluids, electrocardiographic monitoring for cardiac dysrhythmias, defibrillation by electrical shock with external direct current of 200–400 joules, and management of subsequent complications and multiple organ support in an intensive care unit.

## Peritoneal dialysis and hemodialysis

In the intensive care unit, peritoneal dialysis and hemodialysis are used to help treat such challenging conditions as renal failure, multiple organ failure, drug overdose, sepsis (widespread infection), posttrauma conditions, and postoperative renal failure. Blood is withdrawn through intravascular catheters and pumped through a dialysis chamber and back to the patient's vascular system. Among items removed by dialysis are the waste products, urea and creatinine; excess water, potassium, and sodium; drugs; and organic acids and other noxious metabolic end products.

## Circulatory support with intraaortic balloon pumping

The intraaortic balloon pump is the temporary device that is most widely used to assist the failing heart. It is employed when the ventricle of the heart cannot pump enough blood to meet the minimum needs of the body. The balloon, which is placed in the descending aorta, is rapidly inflated in diastole (the time of cardiac relaxation) and rapidly deflated at the onset of systole (the time of cardiac contraction). When the pump is properly synchronized with the heart, the balloon deflation produces a vacuumlike effect that helps the left ventricle to contract. The device also augments diastolic pressure, which improves blood flow and oxygen supply to the heart. Combining the mechanical assistance with the ventricle's own limited ability can permit adequate circulation.

## Extracorporeal membrane oxygenation

Extracorporeal membrane oxygenation equipment is a modification of the apparatus that is routinely used to oxygenate the blood outside the body during open heart surgery. It is used mainly in near-term infants who do not respond to maximum ventilatory and medical support.

## ***Life-sustaining therapy***

Another aspect of critical care is the provision of life-sustaining therapy. Components include administration of intravenous fluids, provision of nutritional support, and control of infections.

## Fluid and electrolyte administration

Fluids are given mainly to replace fluid losses and to provide circulatory support in patients with conditions such as shock or circulatory deficiencies. Intravenous and intraarterial catheters are placed to allow the monitoring of arterial and central venous pressures and the rapid administration of fluids, such as blood, blood components, and various solutions.

Drugs often are used in conjunction with fluid therapy. Such drugs include agents that stimulate cardiac contraction, agents that increase blood pressure, and agents that reduce vascular resistance to cardiac output.

## Nutritional support

In life-threatening crises, nutritional requirements must be maintained. A patient who cannot take nourishment by mouth receives it either via a tube introduced through the nose into the stomach or duodenum, or parenterally (through a vein). Glucose, fat, amino acids, and other substances are given. Total parenteral nutrition can sustain life indefinitely in patients who are unable to eat and have higher than normal nutritional requirements because of sepsis, injury, or prior malnutrition.

## Control of infection

A large percentage of patients in intensive care units have infections that are part of their primary disease or were acquired in the hospital. The latter infections are particularly difficult to eradicate because they are usually resistant to most antibiotics. Infectious agents are identified by culturing bronchial secretions and the fluids from body cavities, wounds, and elsewhere. The sensitivity of each bacterial agent to an array of antibiotics must be tested.

The control of the environment in the intensive care unit is a major problem. Cross contamination between various patients and between patients and personnel must be constantly monitored to prevent outbreaks of infection. *See also:* **Hospital infections (/content/hospital-infections/324000)**

## Other acute crises

Various types of crises are managed by critical care specialists. The following are some examples. Upper gastrointestinal hemorrhage may occur because of bleeding duodenal ulcers, esophagitis, gastritis, perforations of the stomach or esophagus, or other conditions. Lower gastrointestinal bleeding may arise from conditions such as colon tumors, colon diverticula, and hemorrhoids. Therapy usually consists of rapid blood replacement and then, once the patient's condition is stable, operative control of the bleeding source. *See also:* **Hemorrhage (/content/hemorrhage/314100)**

## Acute abdominal crises

Acute catastrophic abdominal conditions can include acute pancreatitis, intestinal obstruction, perforation of a duodenal ulcer, stones of the kidney or ureter, and many other conditions. Many patients with these conditions are admitted to the intensive care unit during their preoperative diagnostic work-up and for stabilization of their cardiorespiratory and fluid and electrolyte status; they may be readmitted postoperatively for management.

## Cardiac emergencies

Among the cardiac emergencies sometimes treated in intensive care units are serious abnormalities of heart rate and rhythm, toxicity from drugs used to treat heart disease, and cardiac tamponade (compression of the heart by blood or fluid in the sac surrounding it). For some conditions treatment can include emergency placement of a pacemaker.

## Coma management

The sudden onset of altered mental status or coma may result from head injury, cerebrovascular accidents (stroke), drug

overdose, postoperative conditions after neurosurgery, meningitis, brain tumors, and various other causes. Patients with altered mental status or coma require special nursing to prevent complications. A major consideration, especially after neurosurgical operations and head injuries, is to monitor the level of consciousness; a change in consciousness is usually the first warning of increasing intracranial pressure, which if not promptly corrected may lead to irreversible brain damage.

## Acute endocrine disorders

Critical care is used in treating a number of acute endocrine catastrophies that are uncommon but potentially fatal. Examples include severe conditions caused by excessive or deficient thyroid hormone secretion, hypoparathyroidism after thyroid surgery, and adrenocortical insufficiency (Addison's disease). See also: **[Endocrine mechanisms \(/content/endocrine-mechanisms/231700\)](#)**

## Injuries

Trauma from automobile accidents, penetrating injuries from violent crimes, and blunt trauma from falls or assaults pose serious technical and logistic problems that must be rapidly addressed. The injured patient must promptly receive appropriate diagnostic tests, monitoring, and therapy. Sometimes surgery must be undertaken while resuscitation efforts are still under way.

## Hepatic failure and metabolic problems

Critical care also is used in managing hepatic failure and metabolic problems. Hepatic insufficiency or failure can result from conditions such as alcoholic cirrhosis, viral hepatitis, drug reactions, and poisoning. Often infection is present, as immunocompetence is impaired in liver failure. See also: **[Cirrhosis \(/content/cirrhosis/137700\)](#)**; **[Liver \(/content/liver/387400\)](#)**

## Pulmonary problems

Patients whose breathing is seriously impaired by conditions such as pneumonia, asthma, pulmonary embolism (blood clot in the lung), smoke inhalation, and near-drowning may receive critical care. Measures available to assist such patients include use of mechanical ventilators (discussed above), administration of humidified supplemental oxygen through a mask or nasal prongs, and use of bronchodilator drugs.

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## Links to Primary Literature

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