

## Intensive Care Unit (ICU) — Special Employees and Conditions

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**The study of anesthesiology has greatly expanded to encompass in its spectrum the care of the most critical patients in the hospital. This article addresses the basic tenets of the intensive care unit (ICU); its organization, composition, components, modern technical armamentarium and concludes with a prologue to brain death and its determination.**



### Intensive Care Unit (ICU)

The physicians and staff assigned to an ICU have specialized training to care for patients who have life-threatening illnesses or injuries. These patients require close attention from health care providers who may use specialized equipment or medications to support patient recovery.

### Types of intensive care units

Many ICUs are staffed by a multidisciplinary team. Most hospitals will have more than one ICU; each is dedicated to treating certain diseases, disorders, or body organs.

General ICU	Created to manage all critical patients (also known as the Medical ICU)
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Surgical ICU	Manages patients post-operatively or optimizes them pre-operatively
Neuro-ICU	Managed by neurosurgeons and intensivists, typically dedicated to patients with primary neurological or neurosurgical problems (e.g. stroke, head trauma, post-operative brain tumor)
Mobile intensive care unit (MICU)	Specialized field intensive care with capacity for both advanced life care support (ACLS) and resuscitation.
Neonatal ICU	Dedicated to neonates, there is unique attention to asepsis.
Trauma ICU	For patients with life-threatening injuries; typically under the supervision of trauma surgeons and intensivists
Cardiac surgical ICU	Specifically designed to manage patients with cardiac disease; under the supervision of cardiologists, cardiac surgeons, and anesthesiologists
Post-anesthesia care units (PACU)	These may often overlap as a "recovery room," where patients are stabilized after surgical procedures
Coronary care units	For patients with ischemic heart disease; usually managed by cardiologists
Pediatric ICU	Specialized attention to the needs of critically ill infants and children.
High dependency units (HDU)	These are transitory units for patients whose conditions are not serious enough for ICU admission but do require close observation. Sometimes referred to as "Step-Down Units."

## Employees in intensive care units

### The intensivist: ICU physician

The ICU physician is the team leader and is usually a trained intensivist, with advanced intensive care training along with a specialization in medicine, anesthesiology, or surgery.

**Qualification:** Different countries have different qualifying norms for "intensivists." In many countries, the training is divided into medical intensivist and surgical intensivist training. In rural communities, this may be an anesthesiologist or an internist. In Canada, before being qualified, an intensivist must complete specialty training in anesthesiology, internal medicine, general surgery, or emergency medicine prior to entering a two-year residency that is accredited by the Royal College of Physicians and Surgeons of Canada. Residents must pass a Royal College exam before qualifying as an intensivist. In the US, training depends on the type of intensivist (eg. Neurointensivists have specific fellowships that are different from Critical Care Intensivists, who usually lead Medical ICUs).

**Examining a critically ill patient:** the focus of the exam depends somewhat on the patient and the particular ICU. For example, the neonate has different needs to the post-operative adult. However, almost every patient typically undergoes a complete physical exam, with specific attention to the following:

- Head-to-toe assessment
- Special focus on gross neurological exam and level of consciousness
- Pulmonary exam with focus on observing the respiratory pattern and excluding [pneumothorax](#) (in cases of trauma, or after central line placement or other interventions)
- Cardiovascular assessment with emphasis on volume status - often includes cardiac ultrasound and assessment of central venous pressure
- Daily abdominal exam and assessment of bowel sounds
- Assessment for skin lesions, breakdown, [edema](#)

- Focused exam on the areas of greatest concern.

### **The ICU nurse**

The ICU nursing staff are proficient in critical care and adept with intensive care procedures.

**Qualification:** The ICU nurse has extensive clinical experience with additional specialized training in intensive care. This experience is instrumental in assessing patients, reacting quickly to changing conditions, making rapid decisions, administering medications, and working with complex equipment. It is often up to the nurse to manage the patient's changing condition and call the physician if needed.

**Duty:** depending on the type of ICU, a nurse's duties may vary. However, in general, nurses have a high degree of independent responsibility for the patient, and typically include the following, in their shift:

- Complete evaluation at the change of shift (start and end)
- Infuse very potent drugs in a safe manner
- Assess hemodynamics and adjust drugs as necessary
- Assess ventilation frequently
- Manage transducers
- Assess the level of consciousness frequently
- Manage sedation, pain, and muscle relaxation
- Manage continuous [renal dialysis](#); ECMO; transfusion and other procedures.
- Manage end of life care
- Communicate with the patient and family (in collaboration with the physician)

### **The dietician and nutritionist**

Nutrition plays a pivotal role in critical patients' recovery. The dietician or nutritionist helps to optimize parenteral nutrition for every patient.

### **The Physiotherapist (also known as the Physical Therapist)**

**Immobilization** is a frequent complication of critical illness. Complications of immobility include **atelectasis**, [pneumonia](#), [deep venous thrombosis](#), and **pressure sores**. Physical therapists can help alleviate these risks and enhance the patient's recovery over time.

### **The social worker**

Intensive care is very costly, both emotionally and financially. Social workers provide psychosocial support to patients and families, helping them locate resources and cope with their circumstances. Social workers also help enhance communication with families and others while allowing the health care team to remain focused on their unique roles.

### **The ICU pharmacist**

Intensive care unit teams usually include a pharmacist, who can assist with possible drug interactions and recommend the most appropriate drug regime for patients with different co-morbidities.

### **The speech therapist**

The speech therapist is a critical member of the team since many ICU patients are ventilated and cannot communicate verbally, or swallow normally. The speech therapist can help provide speech boards, review swallowing capability (particularly after

extubation), and otherwise enhance overall communication.

### The occupational therapist

In conjunction with physiotherapists, OTs can help provide suitable support and rehabilitation as well as **prosthesis** and **orthoses** for patients to enhance early mobilization and rehabilitation. The OT is an integral member of the team, often helping patients resume Activities of Daily Living (ADLs), such as eating and dressing.

### The Microbiologist

The microbiologist or Infection Control Team can help ensure adherence to **asepsis**, evade **breaches of sterility**, and regulate **infection control guidelines**.

### The medical physics technician

The medical technicians are responsible for maintaining medical equipment, ensuring that all equipment is in safe and working order.

## Common Conditions Treated in the ICU

### Failing organ systems

**Heart failure** - earlier use of left ventricular assist devices (LVAD) as a bridge to heart transplant may reduce mortality.

**Renal failure** - an innovative approach is continuous renal replacement (CRRT); this technique results in fewer hemodynamic changes than hemodialysis.

**Respiratory failure** - this can be caused by many conditions. However, the treatment of Acute Lung Injury, previously known as Adult Respiratory Distress Syndrome (ARDS), has been revolutionized by using much smaller ventilator volumes with a concomitant reduction in ventilator-associated lung trauma and improved outcomes.

### SIRS (systemic inflammatory response syndrome)

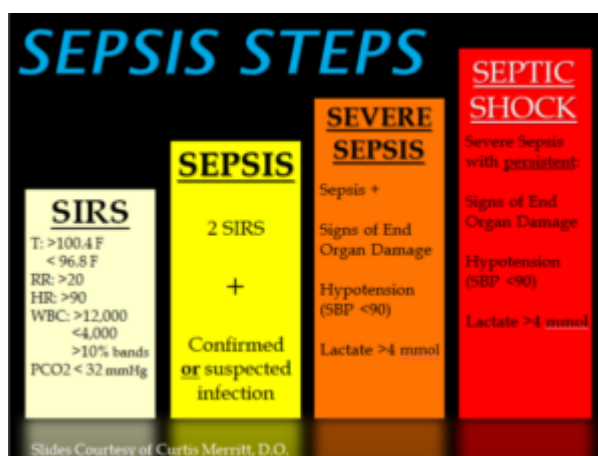


Image: "Teaching slide for help in identifying possible sepsis syndrome, severe sepsis, and septic shock." by Hadroncastle - Own work. License: [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

Systemic inflammatory response syndrome (SIRS) is part of the non-specific response to **ischemia**, **trauma**, **inflammation**, and/or **infection**. SIRS will dictate patient outcomes

and, therefore, are important to recognize and treat as early as possible. Many health care facilities now have “Sepsis Protocols” to help improve care for these patients.

Characterized by **generalized tissue inflammation** with a **general breakdown of the body’s immune system**, it is a part of a continuum.

A patient is said to have SIRS if 2 or more of the following criteria are met:

- A temperature higher than 38 degree Celsius (100.4 ° F) or less than 36 degrees Celsius (96.8 ° F)
- A heart rate of more than 90 beats per minute
- A respiratory rate more than 20 or Pa CO2 less than 32 mm Hg
- A WBC (White blood cell) count more than 12000/cu.mm or less than 4000/cu.mm or more than 10% band forms.

One needs to be aware of the following closely related but distinct terms in a continuum:

- Sepsis: SIRS with a suspected or present source of infection
- Severe sepsis: Sepsis with organ dysfunction, hypotension or hypoperfusion; characterized by the presence of lactic acidosis, systolic blood pressure less than 90 mm Hg or systolic blood pressure drop of more than 40 mm Hg of normal.
- Septic shock: hypotension despite adequate fluid resuscitation.
- Multiple organ dysfunction syndromes: Evidence of two or more organs failing.

SIRS progression can lead to multiple organ dysfunction syndromes (MODS) represents the irrevocable, grave, and undesired consequence of SIRS. Most patients with MODS will die.

A close evaluation for other causes of shock should be made in case a particular patient does not satisfy the SIRS criteria.

**Treatment:** Early [antibiotic therapy](#) is essential. Every hour of delay in administering antibiotics increases mortality by 8%.

**Effective volume management** is crucial. The type of fluid can be artificial colloid, albumin, normal saline, balanced salt, high concentration saline ( 3% or 5% saline) and hypotonic solutions. While the data is unclear regarding the fluid type, there is no doubt that maintaining the **central venous pressure** (CVP) on the higher side of normal is the best approach.

**Effective hemodynamic support** is essential. Depending on the patient’s primary problem, one current drug of choice is **norepinephrine (noradrenaline)**.

## Special Devices in Intensive Care Units

**Skilled emergent clinical acumen** goes hand in hand with a **robust infrastructure to support** the ICU. There are artificial equivalents for many major organ systems. Some of the commonly used devices are outlined below:

### Ventricular assist devices (VAD)

**Mechanical circulatory support (MCS)** devices were studied in the Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) trial. There are various types of ventricular assist devices:

- **Left ventricular assist device (LVAD):** most commonly used.
- **Right ventricle assist device (RVAD)**
- **Simultaneous left and right ventricular assist device:** biventricular assist device (BIVAD)
- **Replacement of both the ventricles:** total artificial heart.

Placed by cardiac surgeons, the basic biomechanics revolve around a balloon placed in the ascending aorta. The LVAD cuff is placed below the [carotid](#) and [subclavian](#) exits from the aorta. The balloon inflates during cardiac diastole, thus increasing the afterload and improving **coronary perfusion**. The balloon deflates during cardiac systole, with a subsequent decrease in afterload, and improved cardiac output. The ECG tracing is modified and the pressure tracing looks quite different from a normal BP tracing.

#### Common indications:

- Stabilize patients prior to cardiac surgery
- Maintain patient until a heart transplant is possible
- Small devices can be implanted and used as a temporary “artificial heart”

## Ventilator



[Image:](#) “Respirator “Evita4” in an ICU.” by Blogotron - Own work.  
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The different configurations available are:

- Positive pressure ventilators
- Transport ventilators
- Neonatal ventilators
- Intensive care ventilators

The modern ventilator is a highly sophisticated piece of equipment that can deliver different modes of ventilation according to the patient’s needs. They are:

**Volume controlled ventilation:** the standard mode; the volume and ventilatory rate are set in accordance with the patient’s arterial oxygen and carbon dioxide levels.

**Pressure controlled ventilation:** This mode is used in patients with high airway pressures who are at risk of barotrauma with volume-controlled ventilation. A maximum

inspiratory volume is set, and the ventilatory rate is modulated per blood gases.

**Pressure assisted ventilation:** facilitates the patient's ventilatory exertions by providing a boost in pressure with each breath to ensure adequate ventilation.

**Positive end-expiratory pressure (PEEP):** improves gas exchange by assuring that lung volume is partially maintained at the end of expiration.

**Bi-level positive airway pressure (BIPAP):** is a non-invasive means of augmenting inspiration. Since it does not require intubation, the patient can still speak and swallow, so it is more comfortable.

**Role of tracheostomy:** In patients with an anticipated need for prolonged mechanical ventilation or failure to wean off the ventilator, **endotracheal tube usage** has its own complications. These patients stand to benefit from tracheostomy that allows the elimination of dead space, allows improved oral hygiene, and reduces the risk of aspiration pneumonia.

#### **Complications of Mechanical Ventilation:**

The complications associated with the use of ventilators include:

- Ventilator-associated pneumonia
- Ventilator-associated lung injury, barotrauma, and volutrauma
- Atrophy of the diaphragm
- Impaired mucociliary transport.

## Continuous Renal Replacement Therapy (CRRT)

Usually ordered by intensivists or nephrologists, and managed by ICU nurses, CRRT offers the following advantages over conventional hemodialysis:

- Less hemodynamic disruption
- Slow and continuous
- A better outcome in [acute renal failure](#), often with complete recovery
- Better stabilization of patients with [chronic renal failure](#), optimizing them to return to hemodialysis after recovery.

## Sedation in the ICU

Sedation, pain control, and muscle relaxation are integral elements of intensive care to enhance patient comfort and compliance.

**Muscle relaxants** should be used with great care in the ICU. It is possible to produce immobility in presence of awareness and pain. If used, a peripheral nerve stimulator should be used to assess the degree of paralysis.

For pain management, **continuous opioid infusion** comprises the standard of care. The patient must be monitored in case doses need adjusting in patients with both renal dysfunction and renal failure.

**Sedative drugs** include benzodiazepines (midazolam, lorazepam), [anesthetics](#) (propofol, ketamine), and central alpha2 agonists (dexmedetomidine, clonidine). Intermittent sedation pauses are highly recommended. No sedation mode has been shown to be superior to others.

Sedation is titrated, using the **Richmond Agitation Sedation Scale (RASS)**.

Score	Term	Description
+4	Combative	Overtly combative or violent; immediate danger to staff
+3	Very agitated	Pulls on or removes tube(s) or catheter(s); is aggressive
+2	Agitated	Frequent non-purposeful movement; fights ventilator
+1	Restless	Anxious but movements not aggressive or vigorous
0	Alert and calm	Interacts with the caregiver
-1	Drowsy	Not fully alert, but has sustained awakening (eye-opening/eye contact) to voice (more than 10 seconds)
-2	Light sedation	Briefly awakens with eye contact to voice (less than 10 seconds)
-3	Moderate sedation	Movement or eye-opening to voice (but no eye contact)
-4	Deep sedation	No response to voice, but any movement or eye-opening to physical stimulation
-5	Unarousable	No response to voice or physical stimulation

## Nutrition in the ICU

When possible, nutrition is given enterally (through the gut), either via a **gastric tube** or an **enteral tube** passed into the duodenum or upper jejunum. Evidence supports improved outcomes in critically ill patients with early enteral nutrition.

**Parenteral mode** of nutrition administration is an alternative. Nutrients can be administered by a central line directly into the circulatory system. This is more complex and expensive. It also has a higher risk of infection and inadequate calorie delivery than enteral nutrition.

## Brain Death

Each country (and in the US, each state), has its own legal criteria for **the diagnosis of neurological determination of death (NDD)**.

The minimum criteria for NDD in Canada are as follows:

- Establishment of **etiology** capable of causing neurological death in the **absence of reversible conditions** capable of mimicking neurological death.
- Presence of **deep, unresponsive coma** with **bilateral absence of motor responses**, excluding spinal reflexes.
- **Absent brainstem reflexes**, as defined by absent gag and cough reflexes and the bilateral absence of corneal responses
  - **Papillary responses** to light, with pupils mid-size or greater
  - **Vestibulo-ocular responses**
  - **Absent respiratory effort** based on the apnea test
- **Absent confounding factors**: excluding the following confounding factors is critical as they preclude the clinical diagnosis of death using brain criteria.

### **Deep sedation (no sedation should be present at evaluation)**

- Unresuscitated shock
- **Hypothermia** (core temperature lower than 34 degrees Celsius; a patient has to be normothermic before being declared brain dead)
- Severe metabolic disorders capable of causing a potentially reversible coma



- Peripheral nerve or muscle dysfunction or neuromuscular blockade potentially accounting for unresponsiveness.
- **Clinically significant drug intoxications** (e.g. [alcohol](#), barbiturates, sedatives, and hypnotics); however, therapeutic levels or therapeutic dosing of [anticonvulsants](#), sedatives, and analgesics do not preclude the diagnosis.

## Summary

The ICU is for patients with life-threatening conditions. There are different types of ICUs, each designed to serve a particular subset of patients in a customized fashion.

The ICU team is large, but typically includes physician-intensivists, ICU nurses, pharmacists, physiotherapists, occupational therapists, dieticians, and social workers, among others.

Each member of the team has unique and specific duties and responsibilities to ensure optimal ICU care.

Some of the special devices found only in the ICU include ventilators, continuous renal replacement therapy, left ventricular assist devices.

SIRS represents a generalized non-specific response of the body to infection, inflammation, ischemia or trauma. Timely intervention is critical to evade progression to MODS.

The sedation used in ICU has equivocal evidence. Intermittent sedation as per RASS is recommended.

Brain death determination has a pivotal role in transplant medicine. Every country has its own protocol. It is necessary to conduct tests to ascertain brain death while ruling out circumstances which closely mimic brain death.

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