

## 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)

ICU epitomizes the critical sections of the hospital where the sickest patients are cared for. The physicians and staff in the ICU have specialized training to allow them to care for the sickest patients. By virtue of the type of patient that is cared for in the ICU, there are drugs used only and highly sophisticated pieces of equipment that are more likely to be found in the ICU. The majority of patients in an ICU will have **more than one critical illness in more than one organ system**.

The concept of **holistic intensive care** dates back to the **1952 Copenhagen polio epidemic**. Mortality rates close to 90% plummeted to about 40%, a drastic reduction, as medical students provided manual positive pressure ventilation. We have come a long way since then. Today's intensive care units are specialized medical areas where medical personnel have access to a wide variety of modern medical technology.

## Types of intensive care units

The operating room is often seen as an ICU. The **anesthesiologists** can be the primary physicians in some ICU locations. ICUs are usually dedicated to primary disorders and can be identified as follows, based on the primary organ system or disorder being treated.

General ICU	Created to manage all critical patients
Surgical ICU	Manages patients who are very sick 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 a for management of patients with cardiac disease and may be supervised by cardiac anesthesiologists
Medical ICU	Designated to manage patients with medical diseases
Post-anesthesia care units (PACU)	These may often overlap as a "recovery room", and render immediate post-operative stabilization to patients following surgical procedures
Coronary care units	For patients with ischemic heart disease; usually managed by cardiologists
Pediatric ICU	Children are not small adults. Their needs, diseases, and responses need specialized attention and hence separate intensive care units.
High dependency units (HDU)	These are transitory step-down units housing patients not serious enough to merit ICU care; but grave enough to demand continuous 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 medicine training after completing a specialization in medicine, anesthesiology or general 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 2-year residency which is accredited by the Royal College of Physicians and Surgeons of Canada. They are obliged to 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 to Critical Care Intensivists, who usually lead Medical ICUs).

**Daily Routine:** the focus of the exam depends somewhat on the unit that the patient is being cared for. 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 of 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 is typically very experienced clinically, with additional specialized training in intensive care. This experience is instrumental in assessing patients, reacting quickly to changing conditions, making rapid decisions, and being comfortable with the use of drugs and 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, these may vary. However, in general, these 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)
- Ability to infuse very potent drugs in a safe manner
- Frequent assessment of hemodynamics and adjustment of drugs as necessary
- Frequent assessment of ventilation
- Knowledge of how to manage transducers
- Frequent assessment of the level of consciousness
- Management of sedation, pain, muscle relaxation
- Management of continuous [renal dialysis](#); ECMO; transfusion and other procedures.
- Management of end of life care
- Communication with the patient and family (in collaboration with the physician)

### **The Dietician and Nutritionist**

Nutrition plays a pivotal role in the recovery of critical patients. 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, as well as enhance the patient's recovery over time.

### **The Social worker**

Intensive care is very costly, both financially and emotionally. The presence of social

workers can help enhance communication with families and others while allowing the team members 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 render the most conducive drug regime to patients with different co-morbidities.

### **The Speech therapist**

The Speech Therapist is a critical member of the team since many patients in the ICU are ventilated and cannot communicate verbally, or swallow normally. The Speech therapist can help provide speech boards, review swallowing capability (particularly after extubation), and others enhance overall communication.

### **The Occupational therapist**

In conjunction with physiotherapists, OTs can assist with help in providing suitable support, rehabilitation as well as **prosthesis** and **orthoses** for patients to enhance early mobilization and rehabilitation. The OT is an integral member of the team, with helping recover 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 **breach of sterility** and regulate **infection control guidelines**.

### **The Medical Physics Technician**

The medical technicians are responsible for the maintenance of the medical equipment, ensure that all equipment is in safe and working order.

## Common Conditions Treated in the ICU

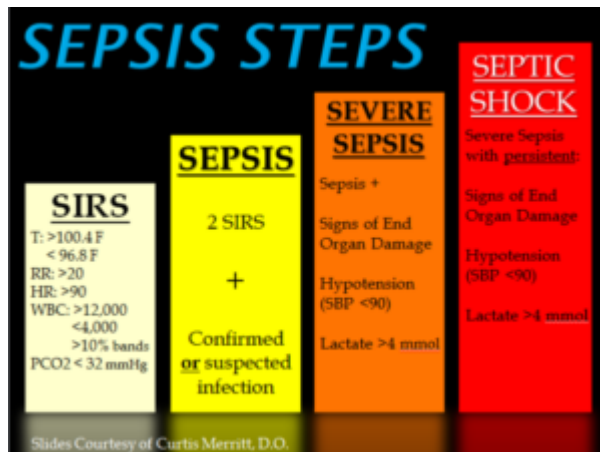
### Failing organ systems

**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 the continuous renal replacement (CRRT); a slow technique with less hemodynamic changes as compared to 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](#)

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 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:

- Temperature more than 38 degree Celsius (100.4 ° F) or less than 36 degrees Celsius (96.8 ° F)
- Heart rate of more than 90 beats per minute
- Respiratory rate more than 20 or Pa CO<sub>2</sub> less than 32 mm Hg
- 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: sepsis with shock: hypotension despite adequate fluid resuscitation.
- Multiple organ dysfunction syndromes: Evidence of 2 or more organs failing.

High in the progression hierarchy of SIRS, multiple organ dysfunction syndromes (MODS) represents the irrevocable grave and undesired consequence of SIRS. Most patients of MODS will die.

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. They are artificial equivalents for many of the major organ systems. Some of the commonly used devices are outlined below:

### Ventricular assist device (VAD)

**Mechanical circulatory support (MCS)** devices were studied in the REMATCH trial. The ventricular assist device can be of various types:

- **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 cuff of the LVAD 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 temporary "artificial heart"

## Ventilator



Image: "Respirator "Evita4" in an ICU." by Blogotron – Own work.  
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The first demonstration of artificial ventilation came from **George Poe** who allegedly revived asphyxiated dogs with his gadgets. We have come a long way since then. 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 which can deliver different modes of ventilation according to the patient's needs. They are:

**Volume controlled ventilation:** the commonest 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 utilized 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 as 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.

**Non-invasive ventilation (BIPAP)** is being increasingly used nowadays and is less invasive since it does not require intubation.

**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 which allows the elimination of dead space, allows improved oral hygiene and reduces the risk for 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 intensivist or nephrologist, and managed by ICU nurse, the following are advantages of CRRT over conventional hemodialysis:

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

## 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 utilized to assess the degree of paralysis.

For pain management, **continuous opioid infusion** comprises the standard of care, adjusting dosing for 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 nonpurposeful movement, fights ventilator
+1	Restless	Anxious but movements not aggressive or vigorous
0	Alert and calm	Heeds to 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)

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



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 central line directly into the circulatory system. This is more complex, expensive and more frequently complicated by 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)**.

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 of less 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 the place in a hospital where the sickest patients are cared for. There are different types of ICU, each designed to serve a particular subset of patients in a customized fashion.

The ICU team is large, but typically includes the physician-intensivist, the ICU nurse, pharmacist, physiotherapist, occupational therapist, dietician, and social worker, 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 device.

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.

Sedation use 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.

## Review Questions

The correct answers can be found below the references.

- 1. Which of the following is not a feature of modern ICU?**
  - A. In-house CT scan in the ICU
  - B. Continuous renal replacement therapy in ICU
  - C. Left ventricular assist device in ICU
  - D. Mechanical ventilation in ICU
- 2. Which of the following is not a defining criterion of SIRS?**
  - A. WBC count > 12,000
  - B. WBC count < 4,000
  - C. Altered sensorium with hypotension
  - D. Temperature > 38 degree Celsius
- 3. Which of the following condition closely mimics brain death?**
  - A. Traumatic extradural hemorrhage
  - B. Severe hypothermia
  - C. Diabetic ketoacidosis
  - D. Hepatic encephalopathy

## References

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**Correct answers:** 1A, 2C, 3B

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