Chapter 25 INTRODUCTION TO CRITICAL CARE

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INTRODUCTION and GOALS

Critical care medicine is unique among disciplines. It is multi-disciplinary and incorporates the knowledge of many different specialties. Defined generally as care for the most acutely ill or injured hospitalized patients, critical care (also referred to as intensive care) is a young specialty. It is a dynamic and growing field with input from many different specialties, nationally and internationally. This chapter will review the history of critical care, discuss the basic principles of hemodynamic and respiratory care of critically ill patients, and will address the importance of quality of life considerations in this acutely ill population.

After studying this chapter you should be able to:

- Identify the key components of a critical care team.
- Understand the initial approach to the management of shock.
- Name interventions found beneficial for the treatment of severe sepsis and ARDS.
- Describe ways to prevent ICU complications
- Understand the value of long-term outcomes in the management of ICU patients.

HISTORY of CRITICAL CARE

The concept of grouping the sickest patients in specific areas of the hospital is an old one, beginning with special needs patients such as post-operative patients and neonates. World War II saw the development of “shock wards” where injured soldiers could be resuscitated. The polio epidemic in the 1940s and then the advent of mechanical ventilation in the 1950s resulted in specialized respiratory intensive care units. In the 1970s, organizations began to form focused exclusively on the management of critically ill and injured patients, regardless of specialty. In 1986, the American Board of Medical Specialties offered a certificate of competence in critical care for physicians certified in medicine, anesthesiology, pediatrics, or surgery.

THE CRITICAL CARE TEAM

While critical care medicine is traditionally practiced in an ICU, in reality critical care is not a location. Providing critical care to a patient means bringing the appropriate resources to bear in a timely fashion. That could occur in a traditional ICU but might also occur in the emergency department, on the acute care floor, or even in the pre-hospital setting.

Staffing the ICU

The specifics of an ICU design and the make-up of the ICU team continue to change. Most national organizations advocate for a “closed ICU” staffed by critical care trained physicians. A closed unit means there is a team of healthcare professionals dedicated to the ICU who do not have responsibilities outside of the ICU. The second part of this national goal is to have these ICU teams staffed by critical care trained physicians, sometimes referred to as "intensivists." This combination of a closed unit staffed by intensivists has been shown to improve outcomes and decrease cost. However, staffing resources have made this challenging to institute in all facilities, and even to date many ICUs are staffed by non-critical care trained physicians. The advent of electronic medical records and computerized charting of vital signs and patient data is changing this landscape as well. e-ICU (electronic ICU) is a system where patients can be remotely monitored by an ICU physician or nurse. When this person is alerted to a problem, he/she can provide the onsite personnel with an alert and with recommended interventions. This is a new technology but is allowing some hospitals, particularly those in more remote or rural locations, without resources to fully staff their ICUs to at least have access to critical care trained personnel.

Who is part of the ICU team?

While certain critical care patient populations require specific care, the vast majority of critical care principles and practice are shared across different types of ICUs. As a result, it is becoming more common to see a multi-disciplinary ICU team with physicians from medicine, anesthesia, and surgery playing the largest roles. The physician is only one piece of the entire ICU team, though. Equally important to the success of ICU patient management is the active involvement by the following groups:

- Critical care nurses
- ICU pharmacists
- Respiratory therapists
- Dieticians/nutritionists
- Social workers/case managers
- Not as commonly a part of the team but becoming increasingly more involved in daily care are physical therapists, occupational therapists, and palliative care consultants.

Ideally all of these key participants would take part in daily rounds. For instance, it is well-recognized that the ICU nurse plays a major role in patient safety, comfort, and outcomes. Increasingly, the ICU nurse is not only present on rounds but actively participates, modeling the collegial relationship critical to this environment. There should be give and take of ideas among team members in order to identify and provide optimal care. It is this multi-disciplinary approach to critical care that sets it apart from many other specialties and also provides much of the satisfaction for those involved.

THE CRITICAL CARE PATIENT

As described above, critical care issues in great part are the same across specialties. This has led to many institutions developing medical-surgical ICUs and teams. However, there are some specialized patient populations who might have unique needs. These may be addressed by housing these patients in separate ICUs or by merely adding these specialists to the care team. These patients include the following:

- Trauma patients
- Burn patients
- Severe sepsis
- Pediatric patients
- Cardiac arrest
- Neurosurgical and neurologic injuries

Similarly, there are unique injuries and illnesses that might precipitate even more specialized care---either by transfer to a special unit, involvement by specialists, or even transfer to another facility. Examples of such diseases include:

- Transplant patients
- Bariatric patients
- Hemodialysis patients
- Alcohol withdrawal and drug use
- Drug overdose and poisonings
- Obstetric patients
- Near drowning patients with severe hypothermia

It is this variety of patients that makes critical care so challenging and constantly provides an opportunity and environment in which to learn. The vast array of diseases and physiologic processes that a critical care physician will encounter demands ongoing familiarity with a wide array of specialties.

COMMON ICU SYNDROMES

Management of Shock

Perhaps one of the most common scenarios facing an ICU physician is the management of a patient in shock. Basically, this is a patient whose body is demanding more than it can deliver, particularly with regard to oxygen consumption and delivery. The challenge to the ICU team is to identify the cause while resuscitating the patient. This is a situation where one needs to "think" and "do" at the same time, often with incomplete data with which to work.

<u>Where do you start?</u> Regardless of the type of shock (Table 1) and thus the cause of the underlying problem, it is critical for the patient to have adequate intravascular volume. This is most evident in the patient who is actively bleeding but is true as well in the patient who is "third-spacing" fluid out of his vessels into the tissues due to an infectious insult or trauma. This is even true for the cardiac patient who will have trouble maintaining his cardiac output if his preload drops.

Table 1. Types of Shock

Type of Shock	Example
Hemorrhagic	24 year old male in motor vehicle collision with splenic laceration and femur fracture. On admission, heart rate 120, blood pressure 90, poor urine output.
Hypovolemic	78 year old woman with 3 days of nausea & vomiting, signs/symptoms of urosepsis. Presents confused, hypotensive, and clammy.
Anaphylactic	16 year old girl at a sleep-over. After watching movies

	and munching on snacks, she breaks out in hives and starts having trouble breathing. She is tachycardic and hypotensive.
Neurogenic	30 year old man out with friends on an ATV. Although helmeted, when his ATV rolls over, he suffers paralysis to his lower extremities. In the ER, he is bradycardic and hypotensive.
Cardiogenic	60 year old man with known history of heart disease. Acute onset of chest pain with diaphoresis, nausea, and trouble breathing. He is tachycardic and hypotensive on admission.

<u>How will the patient manifest shock?</u> Shock usually presents with evidence of poor end-organ perfusion. Be aware that hypotension may be the <u>last</u> sign of shock to present, particularly in young patients. Normal blood pressure does not necessarily mean the patient is out of shock. Some of the main organ systems to monitor include the following:

- Renal (decreased urine output)
- CNS (confusion, lethargy)
- Skin (cold, clammy, poor capillary refill)
- Mesentery (abdominal pain)

<u>How do you treat shock?</u> As evidenced by the examples in Table 1, many patients, regardless of their underlying cause, may present with similar symptoms. The history (from the patient, family, or emergency medical personnel) may be of crucial help. However you may not have enough information to immediately diagnose the underlying cause. While you obtain diagnostic testing (these may include a chest x-ray, laboratory tests, other radiographic imaging), you will start by ensuring adequate intravascular volume. In most cases (except obvious congestive heart failure with volume overload) that means a challenge of isotonic fluids. You will continue with fluids, monitoring the effect of therapy. Other adjuncts you will consider will be to ensure an adequate airway and effective ventilation (remember the ABCs!), consider the effects of drugs or medications the patient may have taken, and consider the need for vasopressor or inotropic medications. As you further determine the cause, other interventions specific to the patient (e.g. angioplasty for acute MI, thrombolytics for acute massive pulmonary embolism) may come into play.

<u>How do you monitor the effectiveness of your resuscitation?</u> Both non-invasive and invasive monitoring play a role in the assessment of the effectiveness of your resuscitation (Table 2). You're hoping to see reversal of the signs/symptoms of shock that initiated your care of this patient. For instance, if the patient had poor urine output (e.g. < 0.5 ml/kg/hr), this improves with fluids or other support. Monitoring the response to fluids is a key component----in other words, give fluids and see if the heart rate, blood pressure, urine output, or perfusion (e.g. capillary refill) improves. Invasive monitoring can include blood markers of overall perfusion (e.g. lactate level, base deficit, venous saturation). Other invasive monitoring may include a central venous catheter to monitor the central venous pressure (CVP) or a pulmonary artery catheter to monitor pulmonary capillary wedge pressure (PCWP), pulmonary artery pressures, and cardiac output. Some of these catheters can also monitor right-sided parameters and provide

continuous mixed venous saturation values. The trend with new technology is for less invasive monitoring. Examples include the LiDCO™ monitor which estimates cardiac output based on arterial waveform analysis. Similarly, bedside echocardiography is playing an increasingly important role in evaluated volume status as well as left and right heart function and response to therapy.

Table 2. Invasive and non-invasive monitors of perfusion

Non-invasive (or less invasive) Monitoring Techniques	Invasive Monitoring
Clinical exam Mental status Urine output Capillary refill Skin cool/clammy or warm	Central venous catheter Central venous pressure Central venous saturation
Blood tests Lactate Venous saturation Base deficit	Pulmonary artery catheter Pulmonary artery pressure Pulmonary capillary wedge pressure (PCWP) Cardiac output Mixed venous saturation
Arterial waveform analysis	
Echocardiogram	
Clinical response to fluid bolus	

Diagnosis and Treatment of Severe Sepsis

Severe sepsis is unfortunately a common admitting diagnosis in the ICU. Until recently there were no direct interventions other than supportive care. Defined as shock with evidence of or suspicion of infection, severe sepsis can have a mortality of 50-60%. In managing a patient with presumed severe infection, one of the most important early interventions is early resuscitation and early institution of appropriate antimicrobial therapy. 2 additional approaches have recently been studied in this population. One is the use of Activated Protein C (*Xigris*®). It works as an anti-inflammatory agent, anti-coagulant, and fibrinolytic agent, essentially helping to minimize the micro-thrombi that can lead to organ failure. Its use, in appropriately sick patients, resulted in a 19% reduction in mortality. The second approach in sepsis is an approach called "early goal directed therapy." The intent here is early optimization of resuscitation efforts, in addition to antimicrobials and any other pharmacologic agents. Fluids, blood, vasopressors, and inotropes are used to maintain a mean arterial pressure (MAP) $\geq$ 65mmHg, CVP$\geq$8-12mmHg, urine output $\geq$ 0.5ml/kg/hr, and ScvO2 (central venous saturation) $\geq$ 70%. With these interventions, physiologic parameters and mortality were improved.

Care of the ARDS Patient

Competence in managing shock and sepsis is key for any ICU physician, as is the ability to recognize, diagnose, and treat Acute Lung Injury (ALI) and the Acute Respiratory Distress Syndrome (ARDS). More information about the pathophysiology of this disease process can be found in Chapter 17. Here we will focus on recognition and treatment of this syndrome. ALI and ARDS are essentially the same process, now more commonly covered under the more global term ALI, as defined by the American-European Consensus Conference (AECC). Both consist of bilateral opacities on chest radiograph, hypoxemia ($PaO_2/FiO_2 \leq 300$ for ALI and ≤ 200 for ARDS), and no evidence of left atrial hypertension (i.e. no heart failure; if pulmonary capillary wedge pressure available, it should be $\leq$ 18mmHg) [Table 3]. ARDS just represents the slightly more hypoxemic version of ALI, but both have the same presentation, physiology, and outcomes.

Table 3. AECC Definition of ALI and ARDS

	PaO_2/FiO_2*	CXR	PCWP
ALI	$\leq$ 300 mmHg	Bilateral infiltrates seen on frontal chest radiograph	$\leq$ 18mmHg when measured or no clinical evidence of left atrial hypertension
ARDS	$\leq$ 200 mmHg		

*regardless of PEEP

How can ALI be recognized? ALI (or for that matter any disease) can only be treated if it's diagnosed, and only diagnosed if it's looked for. A key component to applying the therapeutic interventions for ALI is to develop a rigorous approach to screening patients to determine whether they meet the criteria for ALI. This includes a review of labs, radiographs, and clinical history.

Once recognized and diagnosed, how can ALI be treated? Until recently there were no known therapeutic interventions for ALI. However, the ARDS Network conducted a study comparing lower vs higher tidal volumes. The lower tidal volume group (6 ml/kg PBW) showed a 22% reduction in mortality. Key to this intervention was the "dosing" of tidal volume based on predicted body weight (PBW) not actual body weight which does not necessarily predict lung volume. This intervention was applied and found beneficial even in patients with good lung compliance. The theory is that the stretch itself is harmful, not just barotrauma that can occur with high lung volumes. The stretch appears to precipitate a cascade of inflammatory mediators that may contribute to the end-organ failure seen in ALI patients. A second intervention, also studied by the ARDS Network, showed that once ALI patients were no longer in shock, that a fluid conservative strategy (aiming for a CVP of <4 mmHg) led to fewer days on the ventilator and in the ICU.

PREVENTION of ICU COMPLICATIONS

The management strategies described above for shock, severe sepsis, and ALI are good examples of the interventions now being applied that have reduced mortality in the ICU. Even without these interventions, overall mortality has improved over the last 20 years, in part due to a better understanding of the risks of being in the ICU and how to prevent them. No matter what injury or illness your patient has, once you've applied known therapies, then the next step is to minimize if not prevent complications associated with being in the hospital and ICU (Table 4).

Table 4. ICU Complications and Possible Ways to Prevent Them

ICU Complication	Intervention to try to prevent

Ventilator Associated Pneumonia (pneumonia occurring in patients on ventilators for > 48 hours)	Proven: Head of bed elevation $\geq$ 30° Possible: Subglottic suctioning (to minimize aspiration of secretions); antimicrobial coated endotracheal tubes; oral care with chlorhexidine
Deep venous thrombosis	Mechanical and/or pharmacologic prophylaxis
Central line infection	Full barrier precautions during insertion; Anti-microbial coated or impregnated catheters
Stress gastritis	Enteral feeding and/or acid suppression
ICU Psychosis/Delirium	Daily sedation “vacations”; maintain day-night cycle

“HOT TOPICS” in the ICU

Despite active research (both basic science and clinical trials) with successful interventions in the ICU, we still face untold numbers of diseases, injuries, and syndromes that have no proven therapies. While our desire is to practice Evidence-Based Medicine, the ICU is still relatively short on data. The following topics represent areas of intense need and research and where we can hope to see new practice guidelines in the near future.

- Sedation Management. Recent studies (Kress, et al) have shown that a “vacation” or cessation in sedative and narcotic drips daily can result in fewer days on the ventilator, without compromising patient comfort. These results are now being implemented and further studied, linking this “vacation” to a trial of spontaneous breathing on the ventilator. In addition, the contribution delirium makes to a patient’s ICU stay is only now being fully appreciated and studied.
- Transfusion Triggers. When should we transfuse packed red blood cells (PRBCs) in the ICU? On the one hand, there is a desire to optimize oxygen carrying capacity. On the other hand, there are known deleterious effects of PRBC transfusions, including transfusion reactions, infection, and immune suppression. In addition, PRBCs are a limited resource. Recent studies (Herbert, et al) suggest no deleterious effects of withholding transfusion until a hematocrit of 21 (in patients not having active cardiac ischemia). These results are being further studied, including evaluating the effect (positive or negative) of erythropoiten administration in this population.
- Tight glucose control. It is well understood that uncontrolled hyperglycemia can be harmful. However, most ICU patients are under a stress response with an elevated glucose. Is this a normal, healthy response or is it harmful? A recent study (Van den Berghe, et al) suggested a significant mortality benefit by tightly controlling blood glucose in ICU patients (glucose range 80-110 mg/dl). However, subsequent studies have failed to show this benefit, and in some populations (trauma patients), there appears to be harm with tight control. It is unclear at this time what the right glucose target is, nor whether it is the glucose level itself or the administration of the insulin (an active drug) that is important.

- Nutritional support. With the exception of traumatic brain injured patients who appear to benefit from early nutrition, no definitive evidence currently exists to support early vs late eneteral nutrition in medical or surgical patients. Many patient populations are known to be catabolic (e.g. burn patients, trauma patients, septic patients) with higher nutritional needs. The involvement of a dietician is helpful to target a feeding goal and assess the effectiveness of the chosen strategy. Whether feeding should be initiated early or delayed is still under review.

SUCCESS IS ABOUT MORE THAN SURVIVAL

Many times after we've cared for a particularly sick ICU patient, we feel total success just to have the patient survive, let alone be discharged from the ICU or hospital. However, as technology advances and our ability to save more and more people increases, we are faced with the recognition that many of these people's lives are irrevocably altered either due to their injuries (e.g. head injured patients) or illness. As critical as it is for us to stay up to date on recent medical advances, we also must be alert to the patient's and family's wishes regarding goals of care. This recognition has led to a nationwide focus on Patient and Family Centered Care, a program intended to improve the in-hospital experience for patients and families but also to address their long-term needs.

In an effort to address these needs, clinical trial investigators have recognized the need to study more outcomes than just physiologic and mortality. More and more studies are incorporating assessments of quality of life, depression, post-traumatic stress disorder, and physical functioning. It may be that we don't find a mortality benefit with our next study but could find a marked benefit in quality of life, arguably an equally valuable goal.

To help ICU physicians, nurses, and the entire ICU team better address patients' and families' needs, many ICU teams are incorporating the principles of palliative care into their critical care curriculum and approach. Many are partnering with palliative care experts and consultants to help families optimize their ICU experience. The focus is not on end-of-life or withdrawing life support, but rather ensuring that our interventions are working for the patient and his/her overall goals of care, not just survival.

FURTHER READING and RESOURCES

General information about critical care, including clinical guidelines and position statements:

American College of Chest Physicians: www.chestnet.org

American Thoracic Society: www.thoracic.org

Marino, ed. The ICU Book, 3rd ed. Lippincott, Williams, & Wilkins, 2006.

Society for Critical Care Medicine: www.sccm.org

Articles about Sepsis Management

Bernard, et al. N Engl J Med 2001;344:699-709. (Activated Protein C)

Rivers, et al. N Engl J Med 2001; 345:1368-77. (Early goal-directed therapy)

Articles about ARDS

ARDS Network. N Engl J Med 2000; 342:1301-1308. (Low tidal volume study.)

ARDS Network. N Engl J Med 2006; 354:2564-75. (Fluid strategy in ALI.)

Articles/guidelines about Sedation Management, Transfusion Triggers, Glucose control

Corwin, et al. JAMA 2002;288:2827-35 (Erythropoiten paper.)

Hebert, et al. N Engl J Med 1999;340:409-17. (Transfusion triggers.)

Kress, et al. N Engl J Med 2000;342:1471-7. (Sedation vacation.)

Van den Berghe, et al. N Engl J Med 2001;345:1359-67. (Tight glucose control.)

STUDY QUESTIONS – Introduction to Critical Care

1. The Critical Care Team is usually made up of <u>all but which one</u> of the following personnel:
    a. ICU nurse
    b. Pharmacist
    c. Risk management
    d. Dietician
2. Which of the following is the <u>least</u> useful as a marker of perfusion?
    a. Urine output
    b. Mental status
    c. Blood pressure
    d. Capillary refill
3. Which of the following is a proven therapy for treating patients with severe sepsis?
    a. Heparin
    b. Coumadin
    c. Propofol
    d. Activated Protein C
4. In patients without evidence of active cardiac ischemia, what is the recommended threshold at which to transfuse packed red blood cells?
    a. 18
    b. 21
    c. 25
    d. 30