Interventional Critical Care

A Manual for Advanced Care Practitioners

Dennis A. Taylor
Scott P. Sherry
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Editors

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Foreword by
W. Robert Grabenkort and Ruth Kleinpell

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Editors
Dennis A. Taylor
Carolinas HealthCare System
Charlotte, NC, USA

Ronald F. Sing
Carolinas HealthCare System
Charlotte, NC, USA

Scott P. Sherry
Department of Surgery
Oregon Health and Sciences University
Portland, OR, USA

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Foreword

"By failing to prepare, you are preparing to fail."

Benjamin Franklin

Increasingly, hospital systems and healthcare leaders are incorporating advanced practice providers to supply a 24/7 clinician presence in the intensive care unit (ICU). Nurse practitioners (NPs) and physician assistants (PAs) are an increasingly important component of the nation's healthcare provider pool, and it has been identified that the addition of NPs and PAs to ICU teams is a strategy to meet ICU workforce needs. As NPs and PAs assimilate into this new role, guidance is needed to assume proficiency in the role through mentoring and self-study. This text, *Interventional Critical Care: A Manual for Advanced Care Practitioners*, is a needed resource for these practitioners. In providing instruction on many of the technical skills needed to practice in the acute and critical care environment, the text is a useful reference for novice as well as experienced practitioners. The scope of content covers topics related to essential aspects including credentialing, patient safety considerations, billing and coding for procedures, as well as a review of a number of invasive skills commonly performed in the management of acute and critically ill patients. The insightful chapters are designed specifically for NPs and PAs to assist in learning the procedural techniques performed by the bedside critical care provider. Each chapter is authored by an experienced practitioner describing not only the technical aspects of the procedure but also the clinical indications and pertinent practical considerations. The editors have done a thorough job in choosing a wide range of procedures, and the chapter authors are seasoned practitioners who have performed the skills and share their expertise. This text will undoubtedly be an essential reference for NPs and PAs practicing in the ICU setting. We thank the editors for having the foresight to work on preparing the text and the chapter authors for sharing their knowledge and expertise to enhance NP and PA roles in the ICU.

Atlanta, GA, USA — W. Robert Grabenkort, PA, MMSc, FCCM
Chicago, IL, USA — Ruth Kleinpell, PhD, ACNP-BC, FCCM

Preface

Over the past 10 years, the utilization of advanced practice providers (APPs) in both the intensive care unit (ICU) and operating room (OR) has increased dramatically. With this surge in specialty providers, many educational programs have had difficulty providing the necessary didactic, psychomotor and affective skills, and experiences. These are skills that are necessary for the APP working in these areas and for facility credentialing and privileging that would allow APPs to practice to the full extent of their license and ability. In many cases, the lack of clinical experiences has contributed to this gap. While APPs are very well grounded in the pathophysiology, pharmacology, and physical assessment of patient care, they may have not been exposed to the indications, contraindications, and technical aspects of performing many of these critical skills.

To fill this knowledge gap, we have envisioned and created a textbook that focuses on improving the knowledge and education of the APP in critical care procedures and skills. The editors and chapter authors of this text were recruited from facilities and programs from across the United States. They all actively practice in the ICU and OR and are considered content experts in their respective fields. All chapters are authored by an APP and/or physician. The majority of all authors are also designated as Fellows of the American College of Critical Care Medicine (FCCM). They have made significant contributions to patient care and the Society of Critical Care Medicine (SCCM).

We hope you will enjoy reading and using this text as a reference in your daily practice in the ICU setting. It has been a pleasure working with all of the chapter authors and contributors. We, the editors, would like to express our appreciation to Patricia Hevey, Sonya Hudson, and Sarah Landeen at Carolinas HealthCare System for their contributions to editing and coordinating the efforts of this work. We also express our appreciation to Michael Koy at Springer Publishing for all of his contributions and work on this project.

Charlotte, NC, USA — Dennis A. Taylor, DNP, ACNP-BC, FCCM
Portland, OR, USA — Scott P. Sherry, MS, PA-C, FCCM
Charlotte, NC, USA — Ronald F. Sing, DO, FCCM

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Dennis A. Taylor, Scott Sherry, and Ronald F. Sing

1.1 Introduction

Many highly educated and experienced personnel staff the intensive care unit. This chapter will describe the education and roles of many of these staff. There have been significant discussions in the literature regarding communication, direction, and coordination of these care teams. Each discipline brings a unique perspective to bear on patient care and contributes to the healing and recovery process.

In addition, patient monitoring and ventilation options are better addressed in the ICU setting. More sophisticated ventilators located in the ICU provide better ventilation and oxygenation options.

Many facilities have adopted "crew resource management or CRM" communication techniques from the aviation profession to facilitate the use of checklists and patient hand-off at change of shifts.

1.2 Critical Care ICU Physicians

In both the medicine and surgery fields, there are physicians who specialize in the treatment of critically ill and injured patients. These physicians often complete a specialized Fellowship in Critical Care Medicine after they complete their medical education and residency programs. There are specialty boards that address practice in this very intensive environment. Critical care medicine is concerned with the diagnosis, management, and prevention of complications in patients who are severely ill and who usually require intensive monitoring and/or organ system support. Critical care medicine fellowships provide advanced education to allow a fellow to acquire competency in the subspecialty with sufficient expertise to act as a primary intensivist or independent consultant.

The educational preparation for these surgical professionals includes 4 years of medical education, 6 years of a surgical residency program, and a 1- to 2-year postgraduate fellowship in critical care and/or surgery. The preparation for those working in a medical ICU includes

D.A. Taylor, DNP, ACNP-BC, FCCM (✉)
R.F. Sing, DO, FACS, FCCM
Carolinas HealthCare System, Charlotte, NC, USA
e-mail: dennis.taylor@carolinashealthcare.org; ronald.sing@carolinashealthcare.org

S. Sherry, MPAS, PA-C, FCCM
Department of Surgery, Oregon Health and Science University, Portland, OR, USA
e-mail: sherrys@ohsu.edu

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4 years of medical education, 4–5 years of specialized medical education in pulmonary medicine, and then a fellowship in critical care medicine as well.

1.3 Critical Care Advanced Clinical Practitioners

Critical Care Advanced Clinical Practitioners, or ACPs, are physician assistants or nurse practitioners who are educated to care for the acutely ill or injured patient in the ICU setting. They have 2 years of postgraduate education in advanced practice nursing or physician assistant studies. They typically have a board certification in the adult to gerontology acute care population of patients. Many have completed a postgraduate fellowship program that focuses on the care of the ICU patient.

The Critical Care ACP has a minimum of a master's degree in nursing or physician assistant studies. Many also have doctoral terminal degrees and some postdoctoral education. They are typically credentialed and privileged (state and facility specific) to perform high-risk, low-volume, and high-acuity procedures such as:

Advanced airway management including emergent cricothyrotomy
Placement of central venous lines (with and without ultrasound)
Placement of arterial monitoring lines
Placement and removal of chest tubes
Thoracentesis and paracentesis
Placement of dialysis catheters
Placement of pulmonary artery monitoring catheters
Complex wound management including debridement
Functioning as a surgical first assistant
Focused abdominal sonography for trauma (FAST) exams

1.4 Clinical Pharmacists (PharmD)

Critical care clinical pharmacists are a vital contributor to patient outcomes. They often guide antibiotic stewardship, sedation, and pain control guidelines utilized in the critical care settings. They are often participants in multidisciplinary rounds and are a great resource for teaching in educational settings.

The profession of pharmacy evolved over the last century from a discipline that focused on pharmaceutical products into one that primarily focuses on the patient and the optimal delivery of pharmaceutical care. The curricula in most pharmacy colleges and universities have changed significantly to reflect this transformation. Courses in pharmacotherapeutics, pharmacokinetics, pathophysiology, human anatomy and physiology, physical assessment, and pharmacoeconomics have been added to prepare graduates for careers as clinicians. Furthermore, pharmacy graduates can pursue additional training by completing residencies or fellowships in their areas of interests, which can include critical care [1].

1.5 Registered Respiratory Therapists (RRT/RCP)

Respiratory therapists provide the hands-on care that helps people recover from a wide range of medical conditions [2]. Registered respiratory therapists are found:

- In hospitals giving breathing treatments to people with asthma and other respiratory conditions
- In intensive care units managing ventilators that keep the critically ill alive
- In emergency rooms delivering life-saving treatments
- In operating rooms working with anesthesiologists to monitor patients' breathing during surgery
- In air transport and ambulance programs rushing to rescue people in need of immediate medical attention

Respiratory therapists are considered the go-to experts in their facilities for respiratory care technology. But their high-tech knowledge isn't just limited to the equipment they use in their jobs. They also understand how to apply

high-tech devices in the care and treatment of patients, how to assess patients to ensure the treatments are working properly, and how to make the care changes necessary to arrive at the best outcome for the patient.

The combination of these skills—hands-on technical know-how and a solid understanding of respiratory conditions and how they are treated—is what sets respiratory therapists apart from the crowd and makes them such a crucial part of the healthcare team [3].

Respiratory therapy programs are anywhere from 2 to 6 years in length resulting in an associate's degree to a master's degree upon completion. In addition, there are now many doctoral-level programs in respiratory therapy [6].

1.6 Physical Therapists

Physical therapists are a valued part of the healthcare team. They work with patients to help restore function, improve mobility, relieve pain, and prevent or limit permanent physical disabilities of patients. They also restore, maintain, and promote overall fitness and health. A physical therapist will examine patient's medical histories and perform tests to measure patient's strength, range of motion, balance, coordination, posture, muscle performance, respiration, and motor function. Physical therapists then develop plans describing a treatment strategy. In addition, they also help to develop fitness and wellness-oriented programs to prevent the loss of mobility before it occurs [4].

Physical therapist education programs integrate theory, evidence, and practice along a continuum of learning. Physical therapists usually need a master's degree from an accredited physical therapy school and a state license. Only master's degree and doctoral degree physical therapy schools are accredited. The Commission on Accreditation of Physical Therapy Education (CAPTE) accredits entry-level academic programs in physical therapy.

Physical therapist education programs include both classroom and laboratory instruction. Physical therapist training programs include foundational science courses, such as biology, anatomy, physiology, and cellular histology. Other physical therapist classes include exercise physiology, neuroscience, biomechanics, pharmacology, pathology, and radiology/imaging, as well as behavioral science courses, such as evidence-based practice and clinical reasoning. Some of the clinically based physical therapist courses include medical screening, examination tests and measures, diagnostic process, therapeutic interventions, outcomes assessment, and practice management.

Physical therapist schools also provide student with supervised clinical experience. This may include clinical rotations which enable supervised work experience in areas such as acute care, ICU, and orthopedic care.

1.7 Occupational Therapists

Occupational therapists and occupational therapy assistants help people across the lifespan participate in the things they want and need to do through the therapeutic use of everyday activities (occupations) [7]. Common occupational therapy interventions include helping children with disabilities to participate fully in school and social situations, helping people recovering from injury to regain skills, and providing supports for older adults experiencing physical and cognitive changes. Occupational therapy services typically include:

- An individualized evaluation, during which the client/family and occupational therapist determine the person's goals
- Customized intervention to improve the person's ability to perform daily activities and reach the goals
- Outcome evaluation to ensure that the goals are being met and/or make changes to the intervention plan

Occupational therapy services may include comprehensive evaluations of the client's home and other environments (e.g., workplace, school), recommendations for adaptive equipment and

training in its use, and guidance and education for family members and caregivers [8]. Occupational therapy practitioners have a holistic perspective, in which the focus is on adapting the environment to fit the person, and the person is an integral part of the therapy team [5]. Occupational therapy programs are anywhere from 4 to 6 years. Postgraduate residencies in specialized areas are also common.

1.8 Speech and Language Pathologists

Speech pathologists, officially called speech-language pathologists and sometimes called speech therapists, work with people who have a variety of speech-related disorders. These disorders can include the inability to produce certain sounds, speech rhythm and fluency problems, and voice disorders. They also help people who want to modify accents or who have swallowing difficulties. Speech pathologists' work involves assessment, diagnosis, treatment, and prevention of speech-related disorders [9].

In most states, one must have a master's degree in speech-language pathology to practice. Some states will only license speech pathologists that have graduated from a program that is accredited by the Council on Academic Accreditation in Audiology and Speech-Language Pathology. Coursework includes anatomy, physiology, the nature of disorders, and the principles of acoustics. Students receive supervised clinical training. Doctoral program are very common in this area as well.

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The Surgical Setting: ICU Versus OR

2

Gena Brawley, Casey Scully, and Ronald F. Sing

As both volume and acuity of hospital populations continue to swell, so does the need for surgical services. Many healthcare systems across the country have found it increasingly difficult to meet those growing needs. Specialization of surgical procedures, lengthy operations, and elective surgeries creates a competition for time in the operating room (OR) that further complicates the already stressed need [1]. Furthermore, advancements in surgical critical care allow for higher complexity and higher-acuity patients to survive longer periods of time and require multiple operative procedures. Often there are multiple patients in the ICU (intensive care unit) with open body cavities that require a staged return to the OR for closure. Unfortunately, there is little ongoing development of strategies and processes to meet the patient's surgical needs in a setting other than the OR. Out of this necessity, the trend toward the ICU as a surrogate operative setting has been developed.

To establish the suitability of the ICU to meet the patient's surgical needs, it is important to understand the requirements of the OR. This ensures that the quality of care is maintained despite the setting the patient is being treated in. Caregivers and providers must keep in mind the patients' clinical needs and clinical status are not different because of the location of procedures; the change requires a heightened need for communication and coordination to limit risk.

An important consideration for performing surgery in the ICU versus operating room is the setup of the room and the ability to perform that procedure in the space provided. The bed is central in the OR as it is in many ICUs with monitoring in place at the head of the bed. Supplies are often readily available in the OR and are easily accessible for operative interventions. The ICU has a stock of supplies that are often used for general nursing care. The ICU's supply of operative equipment is often limited due to space and cost. Many times supplies for bedside procedures will be delivered from the operating room to the ICU (see Figs. 2.1 and 2.2).

One important component is the prerequisite of the "Universal Protocol." This protocol dictates that a pre-procedure verification process occurs prior to the start of the procedure. This includes the site being properly marked when laterality is applicable and that a timeout be performed prior to sedation given for the procedure. The timeout must include the patient's name, procedure to be performed, and any applicable information. The timeout must be verified by the performing provider responsible for sedation. During the timeout, other activities and conversations must be suspended so that all present team members can confirm the patient and procedure.

G. Brawley, ACNP-BC (✉) • C. Scully, PA-C
R.F. Sing, DO, FCCM
Carolinas HealthCare System, Charlotte, NC, USA
e-mail: Gena.Brawley@carolinashealthcare.org; Casey.Scully@carolinashealthcare.org; Ron.Sing@carolinashealthcare.org

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Fig. 2.1 Standard ICU set up including bed, monitor, and ventilator

The Joint Commission delegates that safety practices be in place to ensure the prevention of surgical errors. This includes the Universal Protocol that ensures a proper timeout, verification of procedures and patient, and marking of the surgical site [2]. This occurs whether the setting is the ICU or the OR and must be performed regardless of the surgical scene. The Joint Commission also ensures that standards of sterility are maintained, that appropriate dress for the OR is maintained, and that foot traffic is minimized to maintain sterility and minimize distraction. Many ORs have strict guidelines to ensure that they comply with these recommendations; however, with variation in the bedside OR setting, it can be easy to neglect the full process. Special efforts must be made to maintain the proper procedures despite the circumstances.

Another important aspect of the pre-procedure verification check is to ensure that informed consent is obtained. The goal of this consent is to establish mutual understanding and agreement between the patient or surrogate and the provider who is responsible for the procedure. Informed consent implies that the patient or their decision maker has been fully described the procedure with all material risks, benefits, and alternatives.

Preparation of the patient also needs to be considered. A thorough review of the patient's history, potential complications that could arise due any comorbidity, the current condition, and current status prior to any operation should be considered. Recent anticoagulants and home medications such as aspirin and direct thrombin inhibitors may change the coagulation state of the patient, and without direct access to crossmatched or uncrossmatched blood and blood products on hold, hemorrhage could ensue. Special attention should also be given to patients with liver and renal dysfunction while undergoing an operative procedure either for the OR or

Fig. 2.2 Standard operating room setup

bedside procedure. Furthermore, preparation should be made for the sedation of the patient prior to the procedure. Enteral nutrition should be held due to the risk of aspiration; a sedation or anesthetic plan should be ordered and in place, as well as a backup plan. Patients could have hypermetabolic states and may require additional medications for desired sedative level as well as side effects from sedation. The surgeon and support staff should be prepared with fluid and potential vasopressors should a vasodilatory response occur after administration of sedation, pain medications, and/or paralytic. This is paramount to avoid potential unfavorable hypoperfusion and hemodynamic compromise (see Fig. 2.3).

Some proposed benefits of bringing operative careto the patient's bedside include timeliness, safety, and cost.

2.1 Timeliness

Many surgical services recognize the need to manage an increasing patient population. Both the increasing volume and acuity often exceed the capabilities of standard management. A strategy to streamline efficient care is to transition some of the operative care to the bedside. This decreases OR room requirements and anesthesia services, thereby decreasing wait times and giving the provider more efficiency in their day. Often cases can be scheduled at the bedside alternately with OR cases to minimize the wait between procedures. This is particularly true with bedside procedures that require minimal deviation from standard care. More complex procedural needs will often require the equipment and staff of the OR and

Fig. 2.3 Bedside laparotomy in the ICU

may be subject to the same delays as the case actually being scheduled in the OR.

2.2 Safety

Another noted benefit of using the ICU as the operative setting is that this limits the patient's transport requirements. This is particularly beneficial when the patient is crucially ill and either their hemodynamic instability or significant equipment requirements make their transport on and off the unit exceedingly difficult. "Road trips" can have adverse outcomes such as unintentional equipment removal and alterations in patient's hemodynamic stability. Additionally, transport on and off the unit requires staffing removal from their intended assignments and could potentially affect the care of other critically ill patients if the transports are lengthy or frequent. Szems et al. observed ICU patients that were ventilated and underwent intrahospital transport, despite the high severity of illness, the occurrence of problems related to the transport, were minor and only found to have a rate of 5 %. Most often the common complications of the transport included tubing, connections, and temporary disconnection of support line. That being said, specific attention needs to be focused on advanced ventilator support and the patient requiring high levels of positive end expiratory pressures (PEEP) that can result in a decreased recruitment with multiple disconnections required with transfers [3].

2.3 Cost

With our changing healthcare economy, the need to deliver cost-effective care to even the complicated surgical patient is a growing consideration. OR procedures entail the additional

room and equipment charges as well as anesthesia fees. This result of moving some operative cases to the bedside can have a significant cumulative savings.

2.4 Potential Issues when the ICU Is an OR

2.4.1 OR Staff

One potential issue with the need to perform operative interventions at the bedside is the limitations of OR staffing ratios. Traditionally, staffing is determined by the number of OR rooms running, volume, and timing of cases. When emergent or semi-emergent cases present to the OR, the resources needed to meet this demand, including staffing, must be reevaluated and redistributed to fit the needs of the schedule. It is important that these needs not significantly disrupt the set scheduled operating room day unless truly emergent.

The OR is a very protocol-driven setting. It is arranged in a consistent manner to allow for quick location and access to anticipated and frequently needed supplies. Bringing the OR staff to the ICU bedside can drive down comfort and efficiency. This often requires the ICU bedside nurse to assist with more than hemodynamic monitoring of the patient.

2.4.2 ICU Staff

ICU nurses are not specifically trained to assist with bedside procedures or operative interventions. Their role is generally to assess the patient's hemodynamic status and tolerance of the procedure. Additionally not being in the OR setting generally means the absence of anesthesia support to assist with the hemodynamic and ventilator care of the patient during the procedure. The primary concern of the provider performing the procedure is the operative intervention at hand. Often this means their role is expanded to include the total hemodynamic management of the patient as well as surgical technique. Having respiratory therapy and bedside nursing available and able to support the patient is essential to the successful bedside operation. The more experienced the staff often the more smoothly their support during tense cases.

2.4.3 Equipment

The ideal ICU OR mimics the setup of the actual OR including its layout and access to supplies. For bedside procedures, supplies can often be gathered from stock on the ICU floors. Most critical care units keep sterile supplies, gloves, drapes, and trays for specific surgical procedures often performed or needed emergently. For more complex interventions, supplies often have to be requested and delivered from the OR. This requires transport and setup of the supplies at the ICU bedside. Sterile OR back tables can be delivered fully stocked as if they were remaining in the OR suite; however, these must be staffed to facilitate access as well as maintain correct counts for surgical safety. Some specific equipment necessities such as the radiology, Doppler, ultrasound, electrocautery, and others must be acquired and set up in the ICU. The attainment of these specialty resources often requires communication and timing. The ability to properly use these devices can be affected by personnel experience, availability, and the layout of the room. Some ICU rooms may not be able to accommodate specific procedural needs. A study completed at Yale University from August 2002 to June 2009 looked at the ICU as an operating room for patients on the Emergency General Surgery census. They compared ICU and operative databases specifically focusing on mode of ventilation, type of anesthesia used, and adverse outcomes. They found advanced ventilation was used increasingly from 2002 to 2007 and 2008 from 15 to 40 %, and most cases were performed under deep sedation [1]. Also, they noted that advanced ventilation may have influenced the choice of operative location. Unexpected issues that were noted during the ICU operations included recurrent hemorrhage, need for specific instrumentation not present during initial planning, space, and device failure (see Figs. 2.4, 2.5, and 2.6) [4].

Fig. 2.4 Back table setup in the ICU

2.4.4 Backup

A very important consideration for the provider in the bedside OR setting is to anticipate backup plans that may need to be implemented should unforeseen circumstances arise. In the OR there is the possibility of extra staffing that can be shifted to accommodate the needs of an increasingly difficulty or increasingly unstable patient. Often at the bedside, experienced OR staff is limited, and additional surgical support may be delayed by location challenges. The surgeon or provider must know their available resources and when to call for backup early to ward off adverse outcomes. Specific issues that should be anticipated and require preplanning include unexpected hemorrhage, patient hemodynamic instability, need for specific instrumentation, and potential for device failure. Often finesse in managing these unforeseen circumstances comes from experience and comfort in operating outside of the standard OR suite. This builds confidence and eases one's ability of how to react.

A final backup plan would necessitate the transition of the patient to the OR suite when the procedures can no longer be safely performed at the bedside. This requires quick decision-making and staffing accommodations as well as maintenance of sterility when transitioning care settings.

Bedside procedures performed are as follows:

Fig. 2.5 Back table setup in the ICU aside prepped and draped patient

Emergent

- Cricothyroidotomy
- Tracheostomy
- Tube thoracostomy
- Resuscitative thoracostomy
- Decompression of abdomen in setting of abdominal compartment syndrome
- External fixation
- Fasciotomy
- Uncontrolled hemorrhage

Urgent

- Pericardial drainage
- Reopening of exploratory laparotomy in setting of open peritoneum
- Ultrasound-guided drainage of abscess
- Ultrasound-guided thoracentesis
- Ultrasound-guided paracentesis
- Lumbar puncture

Elective

- Percutaneous tracheostomy
- Percutaneous endoscopic gastrostomy tube
- IVC filter placement
- Various endoscopic procedures

2.5 Bedside Anesthesia

Critically ill patients are subjected to noxious stimuli, unpleasant experiences, and discomfort from general disease states. There are varying degrees of consciousness and memory during the critical state and stay in the ICU. Extra care and attention needs to be focused toward providing comfort in this patient population as well as perioperatively. A number of measures can be taken to provide reduction of the experience of pain, anxiety. Examples of the procedures listed above all require an amount of sedation and analgesic medication; however, there are no set guidelines that determine what is the most appropriate, and it is often left up to the surgeon and ICU team involved in the procedure. Guidelines have been developed by the American Society of Anesthesiologists on nonoperating room anesthetizing locations that offer recommendations on equipment, oxygen, suctioning, and emergency equipment such as

Fig. 2.6 Portable laparoscopic tower, for bedside laparoscopic use

crash cart with defibrillator [5]. This also describes potential monitoring needs and monitoring, which is present in the ICU setting. As previously mentioned, care needs to be taken in interpreting these monitors and action for the negative effects of anesthetic provided. Anesthetic options are limited in the ICU, and adequate gas systems are not available, yet many considerations need to be made and plans individualized when choosing sedation, paralytics, and analgesics [6]. Guidelines for sedation and analgesia in the ICU are present, yet limited surrounding the ICU as an operating room.

Again, it is essential to consider the patient's current state and condition when choosing anesthesia for the procedure. As mentioned above, each medication has caveats on potential harmful effects if not chosen with the patient's history, disease state, and metabolism potential of the individual [7].

2.6 The IVC Filter: A Case Study of Transition to the Bedside

The IVC filter was developed to lower the risk of fatal PE in patients with a DVT of the lower extremity who cannot be anticoagulated or who have a recurrence while on anticoagulation. When indicated the IVC filter is placed after obtaining access to the patient venous circulatory system. This is often obtained by femoral access and cannulation with filter placement into the inferior vena cava under fluoroscopy guidance. Fluoroscopy is necessary to guide appropriate placement in just above the renal veins.

Previously, this technique required the patient's transport to the operative suite or interventional radiology for fluoroscopy guidance. As skill and familiarity with the procedure developed, the trend to move the procedure to the bedside for patients who could not tolerate transport began to emerge. Currently, common practice includes IVC filter placement safely at the bedside with the use of a C arm from the radiology department and a radiology technician for equipment operation. This process facilitates the prompt placement of filters and avoids the potential complications of transporting this frequently unstable patient population.

2.7 Summary

With the growing demand for procedural services and the increasing demand of facilities to accommodate this growth, it is increasingly necessary to use various resources to care for the surgical patient. One such shift is the transition of operative care to the bedside, in essence creating an OR out of the ICU. Over the last several decades, procedures previously performed in the OR, interventional radiology, and the cardiac cath lab can now be performed without incidence at the patient's bedside. Following in these footsteps is the transition of both routine and emergent operative care to the bedside. The benefits of efficiency and cost have been demonstrated; however, the provider must be cognizant of the limitations of the ICU and have a keen knowledge of their facility resources and the ability to successfully perform surgery outside of its previously prescribed area. Recommendations for surgical procedures performed in the ICU are reserved for emergent and simple or routine cases that have adequate preparation and planning.

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Patient Safety

3

Roy Constantine and Ashish Seth

3.1 Introduction

The Institute of Medicine's report, *To Err is Human*, provided awareness on the impact of preventable medical errors and patient safety as a national concern [1, 2]. In 2001, a subsequent publication, *Crossing the Quality Chasm*, provided an urgent call on the redesign of our healthcare system due to fundamental quality gaps [3]. In 2006, both publications inspired the *100,000 Lives Campaign* where claims made prevented 124,000 deaths through patient safety initiatives [4].

To improve the quality of American Health Care through measurements, the National Quality Forum [5] has organized 29 Serious Reportable Events (SREs) into categories. These categories relate to: surgical or invasive procedures, products or devices, patient protection, care management, environmental, and radiologic provisions of care.

The Joint Commission (TJC) [6] accredits and certifies healthcare organizations and recognizes their commitment to high performance standards. The TJC is committed to improve performance standards that help to prevent medical errors or SREs. Sentinel events are unexpected occurrences that can lead to death or serious physical or psychological injury [7]. It is important to implement early strategies for protection and early detection because sentinel events occur with considerable frequency in the ICU [8]. The Sentinel Events Evaluation (SEE) study found medication errors, unplanned dislodgement or inappropriate disconnection of catheters and drains, equipment failure loss, obstruction or leakage of artificial airway, and inappropriate turning off of alarms occurring in the ICU setting. A subsequent study in 2009 found medication errors that resulted in permanent harm or death [9].

The development of patient safety programs can improve teamwork and the overall organizational culture [10]. Key elements in achieving patient safety should first include a plan to develop a process to identify and characterize adverse outcomes of healthcare actions and then secondly to create changes, which will promote learning via the analysis of trends and patterns of adverse and near miss events. One in 10 patients has an adverse event while in the hospital, and more than 40 % of these events are considered preventable. Even though the largest proportion of in-hospital adverse events are operation related (39.6 %), a sizable proportion (7.8 %) relate to procedures in medical specialties [11].

R. Constantine, PhD, MPH, PA-C, FCCM, DFAAPA (✉)
MLPs, St. Francis Hospital—The Heart Center®, Roslyn, NY, USA
e-mail: Roy.Constantine@chsli.org

A. Seth, MBA, PA-C
Critical Care MLPs, St. Francis Hospital—The Heart Center®, Roslyn, NY, USA
e-mail: Ashish.Seth@chsli.org

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Focusing on a needs assessment allows for interventions to aid practice and patient care and avoid life-threatening outcomes. In many instances, this critical step may not take place; therefore, understanding the culture and organizational complexity of the health system in order to advance clinical practice is essential. The philosophy of a safety culture has been reinforced by high-reliability organizations (HROs). Many HROs have originated due to catastrophic environments. Previous lessons have been learned from aviation, nuclear, and other organizations that manage hazards well [12, 13]. In 2008, the Agency for Healthcare Research and Quality (AHRQ) published five key concepts to advise hospital leaders to use when developing and implementing initiatives to enhance reliability: sensitivity to operations, reluctance to simplify, preoccupation with failure, deference to expectation, and resilience [14].

Tools are available to help evaluate new and existing processes [15]. For instance, prediction tools have been developed to forecast the risk of cardiac arrest and early transfer to the critical care setting. The Modified Early Warning System (MEWS) is used to help monitor patients that may experience a clinical deterioration. The score is based on: "respiratory rate, heart rate, systolic blood pressure, conscious level, temperature and hourly urine output [7]." MEWS scores do not include laboratory data, which possibly could enhance sepsis detection [16]. Rather, it is a physiological score that may help prevent delay in intervention or the upgrade of critically ill patients [17]. Additional interventions include the use of the electronic medical record "best practice advisories and early warning scores [18]."

Critical care can be rendered beyond the borders of the ICU [19]. The use of medical record-based screening criteria imbedded into the electronic medical record allows a skilled interventional team to assess patients, especially borderline patients to promote better clinical outcomes.

The informatics surge and the electronic medical record have escalated our ability to obtain instant data, drug information, and radiologic reports. Patient and family-centric approaches [20] in the ICU enhance communication and teamwork. Electronic devices, also known as the "iPatient," should not receive all of our focused attention. Unintended consequences can occur if we are not focused on the actual patient. It is noted that patients and families are now realizing that human technology interfacing may distract from overall safety [21].

3.2 Areas of Safety for Global ICU Care

3.2.1 Infection Control

The Centers for Disease Control and Prevention (CDC) updated their infection control guidelines in 2009. The guidelines were prepared by the Society of Critical Care Medicine (SCCM), the Infectious Diseases Society of America (IDSA), the Society for Healthcare Epidemiology of America (SHEA), the American Thoracic Society (ATS), and the American Society of Critical Care Anesthesiologists (ASCCA), among others. Guidelines have been developed for healthcare personnel who insert intravascular catheters and for persons responsible for surveillance and control of infections in hospital, outpatient, and home healthcare settings [22]. Preventative measures, which are directly related to continuing patient safety, are multifactorial especially when in relation to central venous catheter insertions.

3.2.2 Procedural Training

Approximately 6 million central venous catheters are inserted for hemodialysis, for monitoring central venous pressures, and for fluid administration. As simple as inserting a central line, a systems approach failure can go beyond the practitioner and be directed toward inherent deficiencies that result in the failure [23]. Certain procedures may entail higher failure and complication rates, thus requiring more in-depth training before privileging is granted. Can the aphorism "see one, do one, teach one" actually survive among the shortages that exist in critical care training, but one thing for sure is that a focus on improving training is essential [24].

Controversy exists with the use of this technology during emergent vs. routine conditions and

that the lost art of using "anatomic markings" should not be forgotten [2]. Ultrasound guidance for catheterization of the internal jugular vein compared to landmark techniques has shown advantages over landmark technique [25]. Different individuals acquire the necessary knowledge and skills at different rates. It is recommended that a minimum number of 10 ultrasound-guided vascular access procedures be supervised to demonstrate competency in the technique. Utilizing the ultrasound can decrease the incidence of unintentional injury to the carotid artery, decrease the risk of causing a pneumo- or hemothorax, and improve direct visualization of the guidewire for proper placement in the vein [26].

Process improvements can help to eliminate serious adverse events, which include traditional training methods, simulation training, and the effective use of checklists [27]. Procedural experience, training, and complications vary among trainers. Experience does not equal expertise, especially when new technology is introduced.

3.2.3 Retained Foreign Objects

When performing an invasive procedure, "unintended retained foreign objects" (URFOs) can result in a sentinel adverse event. Objects most commonly left behind include:

1. Soft goods, such as sponges and towels
2. Small miscellaneous items, including unretrieved device components or fragments (such as broken parts of instruments), stapler components, parts of laparoscopic trocars, guidewires, catheters, and pieces of drains
3. Needles and other sharps
4. Instruments, most commonly malleable retractors [28]

3.2.4 Surgical Fires

An estimated 600 surgical fires occur on a yearly basis and can result in devastating outcomes. Most importantly, SURGICAL FIRES ARE PREVENTABLE MEDICAL ERRORS!

Surgical fires can occur if all three elements of the fire triangle are present:

1. Ignition source (e.g., electrosurgical units (ESUs), lasers, and fiber-optic light sources)
2. Fuel source (e.g., surgical drapes, alcohol-based skin preparation agents, the patient)
3. Oxidizer (e.g., oxygen, nitrous oxide, room air) [29]

Identification of a high-risk fire case should be identified prior to a procedure. These same fires can easily occur in the critical care setting, procedural setting, and other settings where patient care is rendered.

3.2.5 Teamwork Models

An important aspect of care rendered in the ICU revolves around understanding safety and error prevention strategies, teamwork, and team leadership [30]. The incorporation of evidence-based teamwork tools [e.g., TeamSTEPPS, crew resource management (CRM)] can enhance communication, performance, knowledge, and overall attitude. TeamSTEPPS is an evidence-based set of teamwork tools aimed at optimizing patient outcomes by improving communication and teamwork skills. The four primary teamwork skills include (1) leadership, (2) communication, (3) situation monitoring, and (4) mutual support. Teamwork outcomes are enhanced by (1) performance, (2) knowledge, and (3) attitude. If there is a concern that a safety error can occur, it is recommended to "stop the line."

Several interventions to overcome personal barriers can be implemented. The two-challenge rule is used when an initial assertive statement is ignored. If a statement is repeated twice, the team member can be challenged and acknowledge that they heard the concern. In addition, TeamSTEPPS also uses an assertive statement called CUS. The pneumonic CUS stands for: I am **C**oncerned! I am **U**ncomfortable! This is a **S**afety Issue! If there is a conflict that is not resolved, then mutually supported escalation to a supervisor or more senior colleague should occur [31].

Crew resource management emphasizes a safe and consistent delivery of care through respectful teamwork [32]. CRM incorporates Teamwork Skills and Hardwired Safety Tool Workshops resulting in implementation of tools and the development of metrics.

Both TeamSTEPPS and CRM focus on principles that treat everyone with respect. They fully support you when you speak up in the interest of patient safety and do not allow any retaliation for expression of concerns.

3.3 The Culture of Safety

"Huddles" are friendly and casual types of discussion that exist prior to a procedure being performed. Discussions can include staffing, equipment needs, and other requirements for the procedure. Important procedural elements in the checklist should minimally include conducting a pre-procedure verification—the correct patient, the correct procedure, and the correct site—marking the procedural site, and performing the time-out. Risk assessments can be integrated into the pre-procedural checklist. The recommended steps in preparation for a procedure can include:

- Identification of the medications being utilized in a procedure. Each basin or syringe should be clearly labeled with the medication or solution that it contains.
- A discussion on how sharps (scalpels, needles, etc.) may be handled (neutral basin) is important.
- An instrument count prior and after a procedure should be incorporated.
- If an insertion kit contains a guidewire for line placement, that guidewire must be accounted for on completion.
- Proper disposal of equipment, supplies, and contaminants is also required.

During the "time-out," everyone stops what they are doing and pays attention to the reader who usually uses a preapproved script. A source document is usually present, and other methods of patient verification may include matching the patient's identification band and date of birth.

The time-out process requires the participation of every member in the procedural area. Agreement may focus on known allergies, medications, blood products, and potential concerns and also include minimally the correct patient, the correct site, and the correct procedure to be performed. Each member in the room will verify these elements by saying that they agree, one at a time. This gives the opportunity of every member to "speak up" if there is a patient safety concern.

If a second procedure is to be performed, then an additional time-out is required. If there is a concern with a safety issue or during the prepping and draping of the patient due to a contamination issue, an outside reviewer can stop the procedure. The safety issue needs to be addressed before moving on.

Upon completion of the procedure, a "debrief" should take place. The debrief should describe what went well, what didn't go well, and what can "the team" do to improve the next time. If all are in agreement, the debrief is completed and recorded. If there is disagreement, with no resolution, a concern report may be filed. A safety committee will assign a safety assessment code score upon receiving a concern report. This assessment compares the probability to the severity of the event as low, medium, or high risk. The concern report is then forwarded to an administrative team to review the issue and meet with the team involved. Many times the issue revolves around equipment, instrumentation, environment, possibly behavior, and other issues. An organization that utilizes a non-punitive approach helps to evaluate whether actions were acceptable or unacceptable.

Other multidimensional approaches can help to minimize errors and improve clinical and economical effectiveness in the ICU [9]. Team cross-check during multidisciplinary rounds can focus on specific quality initiatives. The development of hardwired tools with key indicators that impact outcomes is an important element of the process and has demonstrated improvements in further understanding necessary tasks and procedures [33].

The concept of closed loop communication helps to avoid misunderstandings.

An example includes a hand-off communication tool that provides essential patient management information and especially allows two-way communication with the ability of the receiver to ask specific questions regarding the patient, procedures, test, etc. Other ways of verification include confirming the message by a read back and the sender confirms by saying "yes." If the sender does not get a reply, the statement is repeated until the loop is closed with the appropriate "yes" response. If the response were incorrect, the sender would say negative [31].

SBAR is a communication tool used to transmit critical information.

Situation: What is going on with the patient?
Background: What is the clinical content or context?
Assessment: What do I think the problem is?
Recommendation and Request: What would I do to correct it?

Other communication measures that can be incorporated include a "callout," where critical information can be read out loud by an outside reader informing all members of the team during emergent situations [31].

The Swiss cheese model of accident causation identifies that a series of successive layers of defenses, barriers, and safeguards can result in unintended losses simply due to active failures and associated latent conditions. The image of multiple pieces of Swiss cheese helps to identify the system failures or medical mishaps that occur under the best of intentions [34].

Not being aware of what is going on in the periphery can be labeled as "tunnel vision." A procedural example deals with "fiber-optic cord capacitance." During a laparoscopic procedure, the focus is on the tip of the cautery or laser. For example, little-to-no attention is placed on the fiber-optic cord, which may cause thermal injury to a vital structure. The same can occur when observing a monitor. The focus can be on an individual hemodynamic measure instead of addressing all the findings and understanding the complete picture.

Finally, behavioral errors can lead to an error by slips (human error), taking shortcuts (risky behavior) and blatantly ignoring required safety steps (reckless behavior) [35]. A high anxiety environment should never occur. Recognizing that one is having difficulty in performing a procedure does not mean failure. Escalation protocols should be clearly identified. Many times escalating an issue is not an indication of shame or failure.

3.4 Cognitive Aids

Cognitive aids help to guide users to perform tasks and decrease the number of errors with performance. They are especially helpful in stressful situations where complex steps and possible omissions can occur. "The main difference from guidelines, protocols or standard operating procedures is that they are to be used while the task is being performed [36]."

Recommendations are:

1. Its content must be derived from "best practice" guidelines or protocols.
2. Its design should be appropriate for use in the context of the emergency situation.
3. It should be familiar, in a format that has been used in practice and training.
4. It should also assist other team members to perform their task in a coordinated manner [36].

3.5 Checklists

Healthcare professionals are now increasingly using different approaches to improve patient safety and quality outcomes. Methods to reduce patient harm and eliminate medical errors are being monitored in the form of the checklist. Atul Gawande, MD, in his book, *The Checklist Manifesto*, reviews the positive impact of checklists used in many fields, including healthcare. According to Dr. Gawande, "the volume and complexity of what we know has exceeded our individual ability to deliver its benefits correctly, safely, or reliably. Knowledge has both saved us and burdened us" [37].

In the medical setting, checklists can promote process improvement and increase patient safety. Having a formalized protocol will reduce errors caused by lack of information and inconsistent procedures. Checklists have improved processes for patient care in intensive care and trauma units. Along with improving patient safety, checklists create a greater sense of confidence that the process is completed accurately and thoroughly. Working collaboratively with the World Health Organization (WHO), Dr. Gawande examined how a surgical safety checklist was implemented and tested in eight hospitals worldwide. With this checklist, major postsurgical complications at the hospitals fell 36 % and deaths decreased by 47 % [37]. Even with this successful trial, based on several studies, the standardization of surgical processes should not be limited to the operating room as the majority of surgical errors (53–70 %) occur outside the operating room, before or after surgery. This would ensure that a more substantial improvement in safety could be achieved possibly by targeting the entire surgical pathway [38].

In another study, two surgical teams participated in a series of simulated emergencies. Each team performed 8 simulated operations in which one or more crises existed. The teams were randomly selected and managed 4 scenarios with a checklist and 4 from memory alone. Checklist use during operating room crises resulted in nearly a 75 % reduction in failure to adhere to critical steps in management. Every team performed better when the crisis checklists were available. Survey responses stated that the checklists made the team feel better, were easy to use, and could be used in a real-life emergent situation, and if there was an intraoperative emergency, they would want the checklist to be used [39].

Ariadne Labs is a Joint Center for health systems innovation at Brigham and Women's Hospital and Harvard School of Public Health. The researchers are devoted to designing scalable solutions that drive better care at the most critical moments in people's lives everywhere. A Crisis Checklists Download Registration form is available to customize the crisis checklists for specific facility usage [40].

The Stanford Emergency Manual is an excellent aid for perioperative critical events. This is a free perioperative emergency manual that contains several critical events as well as crisis management resource key points.

The researchers provide reasons for implementing an emergency manual:

1. In simulation studies, integrating emergency manuals results in better management during operating room critical events
2. Pilots and nuclear power plant operators use similar cognitive aids for emergencies and rare events, with training on why and how to use them
3. During a critical event, relevant detailed literature is rarely accessible
4. Memory worsens with stress and distractions interrupt planned actions.
5. Expertise requires significant repetitive practice, so none of us are experts in every emergency [41].

The use of checklist training can be integrated with TEAMSTEPPS or crew resource management (CRM). In the operating room, the intensive care units, procedural areas, and other venues, these safety tools can be implemented.

3.6 Conclusion

Chassin [42] notes that after nearly 14 years since the Institute of Medicine report (IOM), "To Err is Human: Building a Safer Health System," there is still a widespread overuse of services, there is a need for more effective strategies and tools to address management complexities in healthcare, and the cultures of most American hospitals and healthcare organizations need change. Leadership's adherence to safe practices needs to eliminate intimidating behavior that does not allow for accurate reporting and results in unsafe conditions.

"Challenges for the future include continued improvement in our systems of care and inclusion of patient safety training in standard educational curricula for health professionals [43]."