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Editorial

Measles: Eliminated but Not Eradicated

If you were a critical care nurse as old as I am, you would most likely have personal experience with the measles virus, gained first-hand while attending elementary school, when you had your turn feeling foul and febrile while wearing a nasty red rash for a week or so. Some of us were provided with an additional opportunity to develop antibodies against measles by contracting both its more benign as well as more serious form. In addition to conferring immunity to future instances of this illness, one or more bouts of measles could also leave us with enduring recollections of how it looks and feels, memories that can serve in later years to recognize the reappearance of measles in children, grandchildren, or patients.

Critical care nurses whose academic and professional years have spanned only the past few decades, however, have had little opportunity to see measles in clinical practice. Since the first measles vaccine licensed in 1963 started eroding the scourge of this disease through the year 2000, when it was declared eliminated in the United States, and throughout the next decade, a median of only 60 cases of measles were reported in the United States annually. As a result, it would be entirely plausible for younger generations of critical care nurses to be more familiar with the measles-mumps-rubella (MMR) vaccine used since 1971 than with specific attributes of the clinical entity itself.

Critical care nurses who are not members of the baby boomer generation may also be less familiar with the morbidity and mortality associated with measles that existed before an effective vaccine was produced. Centers for Disease Control and Prevention (CDC) estimate that between 1963 and 1973, some 3 to 4 million people in the United States were infected with measles annually, of whom 48,000 required hospitalization, 4,000 were left with chronic disability from measles encephalitis, and 400 to 500 died. Measles was then and remains much more than an annoying childhood disease; it can and does disable and kill.

Between 2000 and 2013, the number of measles cases reported annually in the United States has varied from a low of 37 in 2004 to more than 200 cases in 2011 and a few less than 200 in 2013. Nearly all of these cases were imported into this country from outbreaks originating in other parts of the world. A measles case is categorized as imported when exposure to the virus occurred outside the United States 7 to 21 days before the rash developed and the rash occurred within 21 days following entry into the United States, with no known exposure to measles within the United States during that time.

In 2014, the United States experienced 644 cases of measles, the highest number reported in the past 20 years. Through April 24, 2015, the CDC reported a total of 5 outbreaks and 166 cases of measles in the United States, with the largest count in California (see Figure).

Owing to the current resurgence of this disease as well as its potential for causing
serious and even fatal outcomes together with the possibility that some critical care nurses may not be as familiar with it to recognize and protect against it, I am devoting this editorial to providing Critical Care Nurse readers with a synopsis of the essentials that critical care nurses need to know about this disease (see Table), derived primarily from our major resource for that information, the CDC.

Measles has never been eradicated from the United States. As the past 2 years have strikingly illustrated,

![Figure](https://example.com/figure.png)

**Figure** Number of cases of measles in the United States 2001-2015, as of April 24, 2015.

Table - Essential information about measles for critical care nurses

<table>
<thead>
<tr>
<th>Attributes of measles</th>
<th>Essential information for critical care nurses</th>
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<td>Synopsis of measles</td>
<td>Measles is a highly contagious, acute viral respiratory illness with the potential for causing serious complications and death</td>
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<tr>
<td>Rubeola and rubella: shared features</td>
<td>Caused by different viruses</td>
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<tr>
<td></td>
<td>Highly contagious</td>
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<td></td>
<td>Originate outside the United States and are imported by travelers who enter or return to the United States</td>
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<tr>
<td></td>
<td>Transmission is oropharyngeal; susceptible individuals exposed to an infected person who is coughing and sneezing</td>
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<tr>
<td></td>
<td>Produce fever and rash</td>
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<td></td>
<td>Measles-mumps-rubella (MMR) vaccine protects against rubeola and rubella</td>
</tr>
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Distinguishing between types of measles

Rubella and rubeola are different diseases caused by different viruses

- Rubella is a contagious viral disease with mild fever and rash that lasts only a few days before resolving spontaneously.
- About half of patients have no symptoms.
- The most significant concern is the possibility of congenital rubella: a pregnant woman contracting rubella early in her pregnancy may pass it to her fetus, who may then have a 20% or higher chance of birth defects, including cardiac defects, cataracts, deafness, mental retardation, and liver and spleen damage, or experience stillbirth or miscarriage.

Rubeola (“red measles,” hard measles, measles)

- Although most people recover without problems, rubeola can lead to pneumonia or inflammation of the brain (encephalitis).
### Attributes of measles

#### Prevention
- The most effective way to prevent measles is through immunization (vaccination) with the MMR vaccine.
- The MMR vaccine protects against both types of measles.
- The MMR vaccine is about 95% effective in preventing either type.\(^{11}\)
- Children should receive 2 doses of the MMR vaccine. Vaccination is required for school entry.
  - 1st dose at 12-15 months of age
  - 2nd dose at 4-6 years old (may be given earlier, if at least 28 days after 1st dose)
- Infants younger than 12 months should get one dose if traveling outside the United States.
- Any adult 18 years or older born after 1956 should receive at least 1 dose, unless they can show that they have been vaccinated or had all 3 (measles, mumps, rubella) diseases.
- The MMR vaccine may be given with other vaccines.\(^{11}\)
- For health care staff born before 1957, the CDC admonishes that facilities should consider vaccinating staff who do not have laboratory evidence of immunity, laboratory confirmation of past disease, or vaccination with 2 appropriately spaced doses of MMR vaccine.\(^{12}\)
- Health care personnel born in or after 1957, who have not had MMR vaccine and have no serologic evidence of immunity, should receive 2 doses of MMR (1 dose now, 2nd dose at least 28 days later).\(^{12}\)
- Anyone who has ever had a life-threatening allergic reaction to the antibiotic neomycin
- Anyone who has had an allergic reaction to the MMR vaccine
- Pregnant women
- A number of other patient situations warrant notifying the physician if vaccination is considered, including patients who are sick when the vaccination is due and those with severe allergies, cancer, immunosuppressed or immunocompromised states, thrombocytopenia, or recent blood or blood product transfusion.\(^{11}\)

#### Who should be vaccinated?
- Children should receive 2 doses of the MMR vaccine. Vaccination is required for school entry.
  - 1st dose at 12-15 months of age
  - 2nd dose at 4-6 years old (may be given earlier, if at least 28 days after 1st dose)
- Infants younger than 12 months should get one dose if traveling outside the United States.
- Any adult 18 years or older born after 1956 should receive at least 1 dose, unless they can show that they have been vaccinated or had all 3 (measles, mumps, rubella) diseases.
- The MMR vaccine may be given with other vaccines.\(^{11}\)

#### Vaccinations for health care staff
- For health care staff born before 1957, the CDC admonishes that facilities should consider vaccinating staff who do not have laboratory evidence of immunity, laboratory confirmation of past disease, or vaccination with 2 appropriately spaced doses of MMR vaccine.\(^{12}\)
- Health care personnel born in or after 1957, who have not had MMR vaccine and have no serologic evidence of immunity, should receive 2 doses of MMR (1 dose now, 2nd dose at least 28 days later).\(^{12}\)

#### Who should not be vaccinated?
- Anyone who has ever had a life-threatening allergic reaction to the antibiotic neomycin
- Anyone who has had an allergic reaction to the MMR vaccine
- Pregnant women
- A number of other patient situations warrant notifying the physician if vaccination is considered, including patients who are sick when the vaccination is due and those with severe allergies, cancer, immunosuppressed or immunocompromised states, thrombocytopenia, or recent blood or blood product transfusion.\(^{11}\)

#### Preventing transmission
- Transmission is via direct contact or airborne spread when an infected person coughs, sneezes, or breathes. Virus remains infectious in the air and on surfaces for 2 hours after an infected person has left the area.\(^{5}\)
- Covering mouth, especially when coughing, and nose and mouth when sneezing plus good hand-washing help prevent spread.\(^{9}\)

#### Risk factors for measles
- Being unvaccinated\(^{13}\)
- Traveling to countries where measles is more common\(^{13}\)
- Having a vitamin A deficiency\(^{13,14}\)

#### Major clinical features (rubella)
- Symptoms begin 7 to 21 days after exposure (incubation period)
- Prodrome begins 3 to 4 days before skin rash and includes high fever (≥105°F); malaise; cough, coryza, and conjunctivitis
- Toward end of prodrome, a pathognomonic oral enanthema called Koplik spots may appear on buccal mucosa of the cheeks as small white spots on reddened areas
- About 14 days after exposure, a maculopapular rash appears and spreads from forehead to trunk to lower extremities, including palms of hands and soles of feet
- Patients are contagious from 4 days before to 4 days after the rash appears
- Providers should note that immunocompromised patients may not always develop the rash
- Rash gradually fades cephalocaudally
- Measles usually resolves on its own in 7 to 10 days
- Most patients fully recover\(^{4,5}\)

#### Appearance
- Appearance of measles a maculopapular rash
- Appearance of Koplik spots

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*Courtesy of CDC, Public Health Image Library, and Heinz F. Eichenwald, MD.*

*Available at CDC, Public Health Image Library, and Heinz F. Eichenwald, MD.*
## Attributes of measles

### Potential complications
- Complications are more likely in:
  - Children younger than 5 years
  - Adults over 20 years
  - Pregnant women
  - Anyone with compromised immune status
- Common complications
  - Ear infections
  - Diarrhea
- Severe complications
  - Pneumonia: develops in 1 of every 20 children; most common cause of pediatric death related to measles
  - Measles encephalitis: develops in 1 of every 1000 children who get measles; may cause deafness, convulsions, cognitive disability
  - Prematurity, low birth weight delivery
- Long-term complication
  - Subacute sclerosing panencephalitis: arises 7-10 years after acute measles, despite apparent full recovery; rare, fatal degenerative central nervous system disorder; rarely seen in the United States; risk for developing may be higher for those who contract measles before 2 years of age
- Death
  - 1-2 of every 1000 children who get measles die

### Diagnostic findings
- Laboratory confirmation can be obtained via samples of serum, naso- or oropharyngeal swab, or urine
- Diagnosis is confirmed via serologic detection of measles-specific findings:
  - Measles-specific immunoglobulin M antibody
  - Significant increase in measles immunoglobulin G
  - Isolation of measles virus
  - Measles RNA via nucleic acid amplification

### Index of suspicion
- CDC admonishes health care providers to be particularly vigilant for measles in patients who present with fever, rash, and characteristic signs such as the 3Cs (conjunctivitis, coryza, cough), especially if they also:
  - Are not vaccinated against measles; or
  - Live in an area experiencing cases of measles; or
  - Recently traveled (or were exposed to someone who recently traveled) outside the United States

### What health care providers need to do if you suspect a case
- Immediately isolate the patient to avoid airborne transmission
- CDC recommended isolation in health care facilities:
  - Follow respiratory etiquette and airborne precautions
  - Use respiratory protection and follow airborne infection control precautions
  - Despite the low likelihood of MMR vaccine failure, all staff who provide care to infected patients need to follow airborne precautions
- Preferred placement for measles patients is in a single-patient airborne infection isolation room
- Recognize and communicate that patients with measles are infectious from 4 days before through 4 days following appearance of the rash
- Quickly report the case to the local health department
- At first contact with suspected cases, obtain the following laboratory samples for diagnosis and genotyping: serum, throat (or nasopharyngeal) swab, urine, and viral specimens

### Management
- Management is symptomatic, for example:
  - Rest for malaise
  - Lukewarm water sponge baths and mild antipyretics for fever
  - Fluids to avoid dehydration
  - Humidifier or vaporizer for cough

### Additional resources
- Consult the MMR Vaccine Information Statement ([http://www.cdc.gov/vaccines/hcp/vis/vis-statements/mmr.html](http://www.cdc.gov/vaccines/hcp/vis/vis-statements/mmr.html)) and the Childhood Immunization Schedule ([http://www.cdc.gov/vaccines/schedules/easy-to-read/child.html](http://www.cdc.gov/vaccines/schedules/easy-to-read/child.html)).
- In response to the 2015 outbreaks of measles in the United States, the American Academy of Pediatrics issued an early online release of its updated Red Book: 2015 Report of the Committee on Infectious Diseases to provide guidelines for managing measles in pediatric populations.
cases will likely continue to arise as our citizens reenter or visitors newly enter our borders after contracting it elsewhere. Virtually all of the cases reported for 2014 (97%) were associated with importations rather than domestic origins. A majority of the importers are unvaccinated, as are those most likely to develop and spread the disease within the United States. The issue of some US citizens choosing to forego vaccination for themselves and/or their children has the potential for inflicting widespread public health burdens across our nation’s health care system. As the CDC so cogently summarized,6

These outbreaks demonstrate that unvaccinated persons place themselves and their communities at risk for measles and that high vaccination coverage is important to prevent the spread of measles after importation.

Although critical care nurses may not be able to mitigate the introduction of measles into our homeland, we can surely make our contribution to minimizing the potential harm that measles can inflict upon our patients, our unit, our health care facility, and community. Our prompt recognition, isolation, confirmation, reporting, and management of measles can surely assist in curtailing its further penetration into our lives for generations to come.

JoAnn Grif Alspach, RN, MSN, EdD
Editor

References

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CE

Early Mobilization: Changing the Mindset
Emily Castro, DNP, RN-BC, CCRN, Michael Turcinovic, PT, WCC, John Platz, MD, and Isabel Law, RN, MSN

BACKGROUND Staff in the surgical intensive care unit (SICU) had several concerns about mobilizing patients receiving mechanical ventilation.

OBJECTIVE To assess and improve the mindset of SICU staff toward early mobilization of patients receiving mechanical ventilation before, 6 months after, and 1 year after implementation of early mobilization.

METHODS The Plan-Do-Study-Act model was used to guide the planning, implementation, evaluation, and interventions to change the mindset and practice of SICU staff in mobilizing patients receiving mechanical ventilation. Interventions to overcome barriers to early mobilization included interdisciplinary collaboration, multimodal education, and operational changes. The mindset of the SICU staff toward early mobilization of patients receiving mechanical ventilation was assessed by using a survey questionnaire distributed 2 weeks before, 6 months after, and 1 year after implementation of early mobilization.

RESULTS The median score on 6 of 7 survey questions changed significantly from before, to 6 months after, to 1 year after implementation, indicating a change in the mindset of SICU staff toward early mobilization of patients receiving mechanical ventilation. The SICU staff agreed that most patients receiving mechanical ventilation are able to get out of bed safely with coordination among personnel and that early mobilization of intubated patients decreases length of stay and decreases occurrence of ventilator-associated pneumonia, deep vein thrombosis, and skin breakdown.

CONCLUSIONS SICU interdisciplinary team collaboration, multimodal education, and operational support contribute to removing staff bias against mobilizing patients receiving mechanical ventilation. (Critical Care Nurse. 2015;35[4]:e1-e7)

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Development of a Tele-ICU Postorientation Support Program for Bedside Nurses
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The end of the formal unit orientation program is a stressful time of adjustment for nurses hired into critical care without previous critical care experience. Although most units offer reassurance that experienced colleagues will provide the needed guidance, consistent support may not be available for many reasons. Development of a structured postorientation program designed to provide support and ongoing feedback to bedside nurses who have completed orientation is 1 strategy to assist nurses through this period of adjustment. The experience and expertise of the tele–intensive care unit nurse are excellent resources that can be called on to provide the needed support. (Critical Care Nurse. 2015;35[4]:e8-e16)

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Stop the Noise: A Quality Improvement Project to Decrease Electrocardiographic Nuisance Alarms

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Anita Anthony, RN, MS, ACNS-BC, CCRN, PCCN-CMC
Pam Shotts, RN, BSN, CHC, CPC

BACKGROUND: As many as 99% of alarm signals may not need any intervention and can result in patients’ deaths. Alarm management is now a Joint Commission National Patient Safety Goal.

OBJECTIVES: To reduce the number of nuisance electrocardiographic alarm signals in adult patients on the medical cardiovascular care unit.

METHODS: A quality improvement process was used that included eliminating duplicative alarms, customizing alarms, changing electrocardiography electrodes daily, standardizing skin preparation, and using disposable electrocardiography leads.

RESULTS: In the cardiovascular care unit, the mean number of electrocardiographic alarm signals per day decreased from 28.5 (baseline) to 3.29, an 88.5% reduction.

CONCLUSION: Use of a bundled approach to managing alarm signals decreased the mean number of alarm signals in a cardiovascular care unit. (Critical Care Nurse. 2015;35[4]:15-23)

From June 2009 through June 2012, The Joint Commission received 98 alarm-related event reports.1 Of those, 80 resulted in deaths of patients, 13 resulted in permanent loss of function, and 5 resulted in additional care or an extended hospital stay. In spite of the Safe Medical Devices Act of 1990, which requires hospitals to report deaths and injuries related to medical devices, it is believed that the number of events is grossly underestimated.2 In a recent survey examining attitudes and practices related to clinical alarms, 18% of respondents knew of an adverse event related to clinical alarm problems within the past 2 years that had occurred at their institution.3

CE Continuing Education

This article has been designated for CE credit. A closed-book, multiple-choice examination follows this article, which tests your knowledge of the following objectives:

1. List interventions used to decrease the number of electrocardiographic alarm signals in the cardiovascular care unit
2. Identify the 2 phases of The Joint Commission’s National Patient Safety Goal
3. Discuss interventions identified in the literature that have been shown to reduce nuisance electrocardiographic alarm signals

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In addition to cases reported to The Joint Commission, the lay press has also highlighted deaths related to alarms, most recently, the death of a 17-year-old high-school junior who had come in for a routine tonsillectomy. In addition to failed assessments, the monitoring equipment was not set properly and was muted, and when the patient’s condition deteriorated, staff was not alerted by the equipment. Tragically, the patient sustained brain damage and died 15 days later. These events, along with several other publicized cases, have highlighted the need to address the complex issue of alarm hazard aggressively.

Background Knowledge

Alarm fatigue occurs when alarm signals are so frequent that clinicians are overwhelmed to the point that patients’ safety could be compromised if the alarms are disabled, silenced, or ignored. The problem of alarm fatigue has become so consequential that the ECRI Institute has identified alarm fatigue as the No. 1 technology hazard for 4 years in a row. The interest in this topic is further demonstrated by a recent webinar produced by the Advancement of Medical Instrumentation (AAMI) Foundation Healthcare Technology Safety Institute (HTSI) on alarm fatigue, for which registration reached the maximum capacity at 3500 persons, more than for any other previous conference, and included participants from all 50 states (personal communication, S. Fanta Lombardi, AAMI HTSI, March 5, 2014).

Recognizing the complexity and the increased frequency of patient events related to alarm hazards, The Joint Commission issued a sentinel event alert that urged hospitals to examine the effects of alarms on patient safety, and that alert evolved into a National Patient Safety Goal (NPSG). Previous to this, there had been an NPSG on clinical alarms that was designed to “improve the effectiveness of clinical alarms systems.” That goal had been retired in 2005 but was still able to be surveyed under Environment of Care EC.02.04.01, EC.02.04.03 (CoP Physical Environment 482.41), and under Provision of Care, Leadership and Patient Rights (CoPs: Nursing 482.23 and Patient Rights 482.13 [AAMI HTSI webinar, 2013]).

The first phase of the new NPSG requires hospitals to establish alarms as an organization priority and identify the most important alarms to manage depending on their own internal situations. Phase II is to be implemented by January 2016, when hospitals will be expected to have developed and implemented specific components of policies and procedures related to alarm management. In addition, Phase II includes educating staff and licensed independent practitioners about the purpose and proper operation of alarm systems.

Most research has been focused on identifying the number and types of alarms. In spite of the dire consequences of alarm fatigue for patients, little research has addressed interventions to increase alarm safety. However, limited quality improvement projects specific to electrocardiographic (ECG) monitoring have provided guidance on how to decrease nuisance and/or insignificant ECG alarms. Suggested interventions have included daily ECG electrode changes, use of a standardized approach to ECG electrode changes, individualization of alarms to patients’ needs, and elimination of redundant alarms.

Study Question

The purpose of this quality improvement project was to reduce the number of unnecessary ECG and pulse oximetry (SpO₂) alarms in a 16-bed adult medical cardiovascular care unit (CCU). The study question is, Can a
bundled approach of interventions decrease the number of nuisance ECG alarm signals?

Methods

Ethical Issues

This project was submitted to the institutional review board, which determined that it did not meet the criteria for human subject research.

Setting

The quality improvement project was conducted in a 16-bed, Beacon-certified, adult medical coronary care unit within a tertiary care, Magnet hospital that is staffed for 627 beds. The primary populations of patients are patients with acute coronary syndrome or advanced heart failure and patients undergoing induced hypothermia after cardiac arrest. The physical unit design is a central desk with rooms on either side in a Y shape. The charge nurse frequently silences alarms at the central desk and alerts staff if action is needed, as nurses may be caring for patients at opposite ends of the unit.

Process

In order to determine how to address ECG alarms, an interprofessional team met to discuss and understand our ECG monitoring system. The first step in the process was to collect data to determine the baseline number of alarms being sent to the clinical staff. Capturing the data on the number and types of alarms was challenging, and that process was managed by a senior analyst from the information systems department. Data were collected weekly (7 AM Monday morning to 7 AM the following Monday) and compiled into an MS Excel (Microsoft Inc) spreadsheet.

Alarms signals are those triggered by issues related to either patient or systems. Alarm signals related to patients are those alarms that are specific to a patient’s clinical status, such as arrhythmia or low heart rate. Alarm signals related to systems are triggered by either mechanical or electrical problems.6 The priority of the alarms is divided up according to the seriousness of the problem that is causing the alarm and is dependent on how the manufacturer has categorized the alarm. Alarm priority ranges from a critical level that requires immediate attention to a low level of concern (see Table). Alarms triggered by life-threatening events have the highest priority; these alarms must be acknowledged and silenced at the bedside or central monitor. Serious audible alarms sound, but the noise terminates when the trigger abates. An icon remains on the monitor to notify staff until the alarm has been reviewed and the icon eliminated. Advisory alarms ring and terminate with resolution of

<table>
<thead>
<tr>
<th>Alarm</th>
<th>Default</th>
<th>Change</th>
<th>Grade (priority)</th>
<th>Record/store</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No signal</td>
<td>Off</td>
<td>Off</td>
<td>None</td>
<td>Store</td>
<td>Changed from record to store</td>
</tr>
<tr>
<td>Asystole</td>
<td>On</td>
<td>Change</td>
<td>Life-threatening</td>
<td>Record/Store</td>
<td>Cannot be turned to off</td>
</tr>
<tr>
<td>Electrocardiography invalid</td>
<td>On</td>
<td>Advisory but now sent to mobile device communication system</td>
<td>Record/Store</td>
<td>Sent to mobile device communication system similar to life-threatening</td>
<td></td>
</tr>
<tr>
<td>Heart rate (high)</td>
<td>140/min</td>
<td>160/min</td>
<td>Serious</td>
<td>Store</td>
<td>Changed from record to store</td>
</tr>
<tr>
<td>Heart rate (low)</td>
<td>45/min</td>
<td>30/min</td>
<td>Serious</td>
<td>Store</td>
<td>Changed from record to store</td>
</tr>
<tr>
<td>Sinus bradycardia</td>
<td>40/min</td>
<td>45/min</td>
<td>Life-threatening</td>
<td>Record/store</td>
<td></td>
</tr>
<tr>
<td>Sinus tachycardia</td>
<td>Off</td>
<td>None</td>
<td>Serious</td>
<td>Store</td>
<td></td>
</tr>
<tr>
<td>Supraventricular tachycardia</td>
<td>150/min</td>
<td>140/min</td>
<td>Serious</td>
<td>Store</td>
<td></td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>Off</td>
<td>140/min</td>
<td>Life-threatening</td>
<td>Record/Store</td>
<td>Cannot be turned to off</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>130/min</td>
<td>140/min</td>
<td>Life-threatening</td>
<td>Record/Store</td>
<td></td>
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<tr>
<td>Couple</td>
<td>Off</td>
<td>Off</td>
<td>None</td>
<td>Store</td>
<td></td>
</tr>
<tr>
<td>Bigeminy</td>
<td>Off</td>
<td>Off</td>
<td>None</td>
<td>Store</td>
<td></td>
</tr>
<tr>
<td>Oxygen saturation shown by pulse oximetry</td>
<td>89%</td>
<td>88%</td>
<td>Serious</td>
<td>Store</td>
<td></td>
</tr>
</tbody>
</table>
the trigger; these alarms are the lowest priority. The 4 alarm signals for life-threatening events within our system include alarms for (1) asystole, (2) bradycardia, (3) ventricular fibrillation, and (4) ventricular tachycardia. Alarms for life-threatening events are a small percentage of total alarms, and nurses respond to these promptly. Serious alarms comprise a larger percentage of overall alarms and are often considered nuisance alarms—the trigger for the alarm does not require immediate response and, in fact, may be false.

Next a quality improvement process, a rapid process improvement workshop, was initiated. Similar to other quality improvement methods, rapid changes in practice are planned, implemented, evaluated, and continued or changed depending on the outcomes. Potential interventions that were identified included (1) deletion of duplicative alarms, (2) customization of alarms on the basis of the patient’s need, (3) daily changes of ECG electrodes, (4) standardized skin preparation, and (5) use of disposable ECG monitoring leads. In the CCU, Spo₂ measurement alarms were identified as an additional area for improvement as they accounted for the most false alarms. Further interventions were aimed at decreasing the number of these alarms as well. This quality improvement project began in March 2013 and ended in August 2013.

Potential Interventions

Eliminating Duplicative Alarms Unexpectedly, the monitoring systems had separate alarms for both “tachycardia” and “high heart rate” and, conversely, for both “bradycardia” and “low heart rate.” For example, if the tachycardia and high heart rate alarms were both set to go off at 150 beats per minute, both alarms would be triggered and the nurse would need to silence 2 different alarms. Different levels of alarm significance had been assigned to each alarm, which resulted in multiple alarms.

Adjusting Default Alarms The units’ default alarm settings were carefully evaluated and opportunities to eliminate duplicate alarms and safely reduce other alarms were identified so that alarms that did occur would be actionable and clinically significant. Proposed changes to default alarm settings were approved by an interprofessional governing body and by the medical director to ensure that any issues that might reduce patient safety could be identified in advance. A decision was made to change the alarm settings to provide consistency with the designation: alarms for life-threatening events received the highest priority and an ECG strip would print when triggered. Alarms for events that were not life threatening were changed from record to store. All alarms were stored and viewable.

The most common alarms were for bigeminy and for couplets, accounting for as many as 87% of all alarm signals weekly. These alarms had little relevance because isolated bigeminal and couplet beats are not treated in our current practice, consistent with the results of the 1988 CAST trial, which demonstrated a higher rate of death in patients treated with encainide and flecainide versus placebo. These alarms could also be incorporated into other alarms that could be customized for each patient. After consultation with physicians, we changed the default setting for the bigeminy and couplet alarms to off, with nurses having the option to turn these alarms on if the patient’s condition warranted doing so.

Customizing Alarms Nurses were instructed to ensure that alarms were tailored to the patients’ condition. Appropriate complex size was adjusted to enable the monitor to provide appropriate rhythm analysis. Asystole alarms often were triggered by incorrect readings of paced rhythms, often because of the lack of the “pace detect” function. Activation of this function assists in analyzing and determining paced rhythms, so the system was set with the pace-detect function as a default. The default allowed nurses to focus on other issues related to monitoring patients. Often alarms occurred when the patient was disconnected from the monitor, such as during tests or when the patient was in the shower. Strong encouragement was made to place patients’ monitors on “standby” status, thus decreasing the number of avoidable alarms.

Daily Changes of ECG Electrodes The hospital’s policy for changing ECG monitoring electrodes stated that “patches [electrodes] will be changed every 2 days” consistent with the skills for cardiac monitor setup and lead placement specified in the American Association for Critical-Care Nurses’ (AACN’s) AACN Procedure Manual for Critical Care. For this pilot study, we initiated daily electrode changes.
Standardized Skin Preparation for ECG Electrodes

Skin preparation was based on the AACN’s practice alert for alarm management and included (1) washing the isolated electrode area with soap and water, (2) wiping the electrode area with a rough washcloth or gauze and/or using the sandpaper on the electrode to roughen a small area of the skin, and (3) eliminating alcohol for skin preparation to prevent the skin from drying out.

Use of Disposable ECG Lead Wires

Anecdotally, disposable electrode wires have been associated with a decrease in alarm signals, thus providing a better quality signal and more secure fit to the ECG electrodes, resulting in fewer system alarms related to problems with electrodes or leads (eg, “leads invalid” alarms). In this quality improvement project, a 2-week trial of disposable ECG leads was pilot tested in the CCU.

SpO₂ Monitors

Graham and Cvach demonstrated that one of the largest contributors to the number of nuisance alarms was the pulse oximetry alarm. This alarm is relatively quiet at the bedside but is markedly amplified at the central desk, a function of the monitoring system that cannot be changed. Minimal interventions were identified that could reduce nuisance SpO₂ alarms. Welch demonstrated that by decreasing the threshold on the SpO₂ from 90% to 88%, alarms could be decreased by 45%.

Given the limitations of our monitors, alternative strategies were employed to reduce the number of SpO₂ alarms. The threshold (ie, at what oxygen saturation the alarm would go off) was decreased from 90% to 88%. All patients in the CCU are started on SpO₂ monitoring at admission, and nurses were encouraged to evaluate the appropriateness of continued monitoring after 24 hours and to consult with physicians to discontinue SpO₂ monitoring on patients who were stable on room air, a practice supported by hospital policy. Education was provided to staff on proper selection and placement of sensors. Forehead probes were encouraged for patients who were mobile in an effort to reduce artifact alarms associated with activity.

Analysis

Descriptive statistics were used to identify the changes over time. Patient-related alarm conditions were identified on the basis of physiological conditions: (1) asystole, (2) sinus bradycardia, (3) supraventricular tachycardia, (4) ventricular fibrillation, (5) ventricular tachycardia, (6) arrhythmia: bigeminy, and/or (7) arrhythmia: couplet.

System issues leading to alarms were either (1) ECG leads invalid or (2) ECG artifact. Totals were calculated for the physiological alarm conditions and the system alarm conditions each week (7 AM Monday to 7 AM Monday). The grand total of the summation of the alarm conditions was then divided by 7 (days in the week) to obtain the mean number of alarms per day. The mean number of alarms per day was then divided by the mean daily census for the patient care unit to obtain the rate per patient. In addition, the rate of the alarms for life-threatening events and the rate for the system alarms per day were also divided by the mean daily census to determine the rate of alarm signals by priority.

Results

In this quality improvement project, a bundled set of interventions that included deletion of duplicative alarms, customization of alarm status, daily ECG electrode changes, standardized skin preparation, and use of disposable ECG monitoring leads was associated with an 80% to 90% reduction in ECG alarms in the CCU (see Figure). The baseline data (April 4-11, 2013) revealed a mean of 28.5 total alarm signals per day per monitored bed, of which a mean of 3.58 were system alarms and alarms for life-threatening events. After implementation of interventions (August 12-August 19, 2013), the number of alarms was reduced (3.29 total alarm signals per day per monitored bed, all of which were system alarms and alarms for life-threatening events). After implementation of interventions (August 12-August 19, 2013), the number of alarms was reduced (3.29 total alarm signals per day per monitored bed, all of which were system alarms and alarms for life-threatening events). This change has been sustained, as evidenced by an assessment of the number of ECG alarm signals in December 2013 that demonstrated a mean of 3.05 alarm signals per day per patient.

Despite our changing the threshold for SpO₂ alarm signals from 90% down to 88%, no changes in alarm rates were noted. No adverse patient events were associated with the lower threshold, but the change had little effect on the overall number of SpO₂ alarms generated. Nurses

A 2-week trial of use of disposable leads in the cardiovascular care unit failed to show any significant change in alarm rates.
are encouraged to customize this alarm as indicated, but our current technology has a set delay of 4 seconds and does not support signal averaging.

**Discussion**

In this quality improvement project, we were able to demonstrate an 80% to 90% reduction in the number of nuisance ECG alarms in the CCU that has been sustained (see Figure). This reduction is consistent with other published quality improvement efforts.6,16,18 However, unlike Graham and Cvach,6 we were unable to change the number of oxygen saturation alarms even after decreasing the threshold from 90% to 88%.

Although the intent of ECG alarm systems is to enhance patient safety, published reports indicate that between 72% and 99%26-32 of alarms are false or nonactionable, which actually creates a safety risk. Because of the number of nuisance alarm signals, care providers can experience a “cry wolf” effect, leading to desensitization and alarm system mistrust, so that real events are less likely to be acted on.33-35 Eventually, this situation has led staff to begin to mistrust the alarm system so that real events are less likely to be acted on.33-36 Breznitz36 has termed this the “false-alarm effect” and has posited that the more sensitive a warning system is, the greater is the effect from repeated false alarms because weaker signals will be detected, thus creating more alarm signals. This issue of sensitivity may have been part of the reason for the results in a recently published study,37 which demonstrated that, of 17 “crisis level” alarms that occurred, 16 were ventricular tachycardia alarms, 9 were for artifacts, and none of the alarm signals was for a true ventricular tachycardia. In addition, the 17th alarm signal was for asystole and also was false. These results are particularly distressing because it has been demonstrated that if a person experiences a system to be 10% reliable, then the person will respond 10% of the time.34,38,39 The dire consequences of the number of nuisance alarms has been demonstrated when the alarm limits are extended, disabled, or not returned to their original settings, resulting in patients dying.4,40,41

The most significant change was in number of the bigeminy and/or couplet alarms, which accounted for the vast majority of the alarm signals (ie, 25 of the 28.5 alarm signals per day per monitored bed). After implementation of the quality improvement project, the alarm signals decreased to a low of 0.06 alarm signals per day per monitored bed, which is a 99.7% reduction. This reduction was accomplished without compromising patient safety in that the bigeminy and/or couplets were captured in the number of premature ventricular contractions per minute or the number of premature ventricular contractions in a row.

We were unable to demonstrate a change in SpO₂ alarms. This result was disappointing because nurses find the SpO₂ alarm one of the more irritating alarms. Once we were able to decrease the number of nuisance alarms from the ECG monitor, the SpO₂ alarm became
even more irritating because it was more prominent. We were limited by the fact that our only option was to decrease the alarm threshold because the technology did not support a slight delay to allow for alarm correction (ie, we were unable to change the number of seconds before an alarm is triggered).

Disposable ECG lead wires were not associated with a change in alarms. However, when we started using disposable ECG wires, the rate of alarm signals was so low that no matter what intervention was implemented, the results might have been the same. We suspect that this was not a fair assessment of the use of disposable ECG lead wires.

This quality improvement project using a rapid process improvement workshop provided an approach for implementation of the same interventions on other patient care units within the hospital. The identified interventions were replicated in the cardiovascular surgical intensive care unit, where they yielded equally successful outcomes. This approach will continue to be used as the interventions are implemented throughout the hospital.

Limitations

This was a quality improvement project, and we cannot establish a cause and effect relationship, that is, we cannot say that any one intervention resulted in more or less of a reduction in the number of nuisance alarm signals. In addition, the results are not generalizable. Another limitation is that we do not know the validity of the alarms that we still have, namely, the alarm signals for life-threatening events. As waveforms were not validated, we do not know if the remaining alarm signals were true or clinically significant. However, the number of alarm signals for life-threatening events did not decrease with the pilot study, indicating that we continue to capture the meaningful alarms.

Conclusions

This quality improvement project demonstrated that implementation of a bundle of interventions can reduce the frequency of nuisance alarm signals in patients in a CCU and that the reduction can be sustained over time. However, we were not able to change the number of nuisance SpO₂ alarms, most likely because of the limitations of our technology. CCN

Acknowledgments

The authors thank Jon Christopherson and Louis McGary for their contributions to this work, as we could not have conducted the project without their help and expertise.

Financial Disclosures

None reported.

References


Learning objectives: 1. List interventions used to decrease the number of electrocardiographic alarm signals in the cardiovascular care unit 2. Identify the 2 phases of The Joint Commission’s National Patient Safety Goal 3. Discuss interventions identified in the literature that have been shown to reduce nuisance electrocardiographic alarm signals

1. Which of the following requires hospitals to report deaths and injuries related to medical devices?
   a. Healthcare Technology Safety Institute  
   b. The Joint Commission Sentinel Event Program  
   c. 2015 National Patient Safety Goals  
   d. Safe Medical Devices Act of 1990

2. Which of the following was the stated purpose of this quality improvement project?
   a. Examine the effects of alarms on patient safety  
   b. Identify the most important alarms to manage  
   c. Improve the effectiveness of their clinical alarm system  
   d. Reduce the number of unnecessary electrocardiographic (ECG) and pulse oximetry (SpO2) alarms

3. What was the first step taken to determine how to address ECG alarms?
   a. Data collection to determine the baseline number and type of alarms  
   b. Determining the unit with the highest number of ECG alarms  
   c. Identifying patient populations with tendencies for false alarms  
   d. Initiating a rapid process improvement workshop

4. Which of the following was not one of the steps recommended for the standardized skin preparation before ECG electrode placement?
   a. Preparing the skin with an alcohol pad  
   b. Determining the unit with the highest number of ECG alarms  
   c. Identifying patient populations with tendencies for false alarms  
   d. Using sandpaper on the electrode to roughen the skin

5. Which of the following was an alternative strategy employed to reduce the number of SpO2 alarms?
   a. Ear sensors were encouraged for patients who were mobile  
   b. Education was provided on proper selection and placement of sensors  
   c. Monitoring was discontinued 24 hours after admission to the unit  
   d. The alarm threshold was decreased to 85%

6. What reduction in unnecessary ECG alarms was achieved with the bundled set of interventions included in this quality improvement project?
   a. 20%-30%  
   b. 40%-50%  
   c. 60%-70%  
   d. 80%-90%

7. What were the findings after a 2-week trial of disposable leads?
   a. The leads failed to show any significant change in alarm rates.  
   b. The leads were associated with a decreased infection rate.  
   c. The patches were more secure than the previous product.  
   d. Use was associated with a 50% reduction in ECG alarms.

8. Which definition best describes what Breznitz termed the “false-alarm effect”?  
   a. Alarms that occur when the patient is disconnected from the monitor  
   b. Mistrust of the alarm system so that real events are less likely to be acted upon  
   c. When monitoring systems have duplicated alarm sets at differing levels of significance  
   d. When the monitor company determines the default alarm settings

9. What intervention described by Welch was found to decrease SpO2 alarms by 45%?
   a. Decreasing the alarm threshold from 90% to 88%  
   b. Evaluating the need for monitoring upon admission to the cardiovascular care unit  
   c. Switching to disposable oximetry probes  
   d. Using ear probes for patients who are mobile

10. What intervention was identified as the first phase of the new National Patient Safety Goal?
    a. Hospitals are required to establish alarms as an organizational priority and identify the most important alarms to manage.  
    b. Hospitals will develop and implement policies related to alarm management.  
    c. Staff members will be educated on the proper operation of alarm systems.  
    d. The effects of alarms on patient safety will be examined.

11. Which of the following interventions is helpful to decrease nuisance ECG alarms?
    a. Decreasing the SpO2 threshold from 90% to 88%  
    b. Individualization of alarms to the patient’s needs  
    c. Preparing the skin with alcohol pads  
    d. Changing ECG paces every 72 hours

12. What source was used to determine the standardized skin preparation for ECG electrode placement?
    a. AACN Practice Alert for Alarm Management  
    b. AACN Procedure Manual for Critical Care  
    c. Hospital’s policy for changing ECG electrodes  
    d. Manufacturer’s recommendation for skin preparation

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

1. □ a  □ b  □ c  □ d
2. □ a  □ b  □ c  □ d
3. □ a  □ b  □ c  □ d
4. □ a  □ b  □ c  □ d
5. □ a  □ b  □ c  □ d
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7. □ a  □ b  □ c  □ d
8. □ a  □ b  □ c  □ d
9. □ a  □ b  □ c  □ d
10. □ a  □ b  □ c  □ d
11. □ a  □ b  □ c  □ d
12. □ a  □ b  □ c  □ d

Test ID: C154 Form expires: August 1, 2018  Contact hours: 1.0  Pharma hours: 0.0  Fee: AACN members, $0; nonmembers, $10  Passing score: 9 correct (75%)
New Guidelines for Assessment of Malnutrition in Adults: Obese Critically Ill Patients

Kasuen Mauldin, PhD, RD
Colleen O’Leary-Kelley, RN, PhD

Recently released recommendations for detection and documentation of malnutrition in adults in clinical practice define 3 types of malnutrition: starvation related, acute disease or injury related, and chronic disease related. The first 2 are more easily recognized, but the third may be more often unnoticed, particularly in obese patients. Critical care patients tend to be at high risk for malnutrition and thus require a thorough nutritional assessment. Compared with patients of earlier times, intensive care unit patients today tend to be older, have more complex medical and comorbid conditions, and often are obese. Missed or delayed detection of malnutrition in these patients may contribute to increases in hospital morbidity and longer hospital stays. Critical care nurses are in a prime position to screen patients at risk for malnutrition and to work with members of the interprofessional team in implementing nutritional intervention plans. (Critical Care Nurse. 2015;35[4]:24-31)

Depending on the population of patients and the criteria used for detection, 15% to 60% of patients have some degree of malnutrition when they are admitted to the hospital. Patients in the intensive care unit (ICU) are more likely than other patients to be malnourished or at high risk for malnutrition. Malnutrition in critically ill patients is associated with increased hospital morbidity and mortality, increased risk for infections, compromised immune status, poor wound healing, and extended hospital lengths of stay.

In the United States, the Joint Commission on Accreditation of Healthcare Organizations mandates that every patient have a nutritional screening within 24 hours of admission to an acute care center. The purpose of the screening is to detect patients who are already malnourished or at nutritional risk so the patients can receive early nutritional intervention. Despite the availability of malnutrition screening tools, such as the Nutritional Risk Screening (NRS-2002) instrument, malnutrition continues to be underrecognized. Multiple definitions for malnutrition can be found, and no standards exist for...
standardization in documenting malnutrition nutritional information. In response, the Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition jointly released a consensus statement in 2012 outlining recommendations for the detection and documentation of malnutrition in adults. The statement proposes an etiology-based approach in defining malnutrition that takes into account the role of inflammation. Understanding these current definitions of malnutrition will help critical care nurses recognize the different types of malnutrition syndromes, particularly chronic disease-related malnutrition common in obese critically ill patients.

Appropriate recognition of malnutrition requires knowledge of nutritional assessment methods. Nutritional assessment is the first step in nutritional care, a continual process that includes a diagnosis, intervention, monitoring, evaluation, and periodic reassessment. A nutritional assessment involves gathering information that will provide the evidence for the diagnosis as well as the basis for planning the intervention. In the ICU, critical care nurses have great influence on patients’ outcomes because nurses spend more time at the bedside with patients than does any other health care provider. Critical care nurses and all members of the health care team should have current knowledge of the new guidelines released by the Academy of Nutrition and Dietetics and the American Society for Parenteral and Enteral Nutrition. A systematic, interprofessional team approach to nutritional assessment will prevent delays and oversights in diagnosing and managing malnutrition.

**New Guidelines**

The 3 etiology-based definitions of malnutrition (see Figure) in the new guidelines are starvation-related malnutrition without inflammation, chronic disease-related malnutrition with mild to moderate inflammation, and acute disease- or injury-related malnutrition with marked inflammation. These definitions take into consideration that inflammation (whether chronic or acute) is an underlying factor in the pathogenesis of metabolic alterations associated with malnutrition in disease or injury states.
The first step in nutritional assessment is detecting patients who have compromised intake, loss of body mass, or both.20 A total of 2 or more of the following 6 characteristics are currently recommended for the diagnosis of malnutrition in adults14,15: insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation that may sometimes mask weight loss, and diminished functional status (eg, as indicated by hand grip strength).

Critical care nurses are in a key position to document these characteristics in screening and assessment of patients for malnutrition. Whenever possible, assessment data should be collected by using measurements rather than be obtained from patients’ self-reports or collected from patients’ family members. Table 1 outlines the specific information and data to be collected and used for the detection and documentation of malnutrition. After patients with nutritional risk have been identified, the presence or absence and degree of inflammation should be assessed to determine the type of malnutrition. Table 2 gives parameters that may be useful in assessing inflammation status. Severe inflammation is easier to identify than are other types because clinical signs and symptoms of severe inflammation tend

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Information used in assessment and documentation of malnutritiona</th>
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<tbody>
<tr>
<td><strong>Data to be collected for documenting insufficient energy intake</strong></td>
<td></td>
</tr>
<tr>
<td>Comparison of energy intake vs estimated energy expenditure</td>
<td></td>
</tr>
<tr>
<td>Hourly documentation of nutritional support</td>
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<tr>
<td>Type of nutritional support, feeding rate, volume</td>
<td></td>
</tr>
<tr>
<td>Estimated nutrient needs</td>
<td></td>
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<tr>
<td>Estimated resting energy expenditure determined by using indirect calorimetry or predictive equations (and multiplying by appropriate injury factors)</td>
<td></td>
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<tr>
<td>Estimated protein needs (appropriate range based on clinical state)</td>
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<tr>
<td>Estimated fluid needs</td>
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<td><strong>Data to be collected for documenting weight loss, loss of muscle mass, loss of subcutaneous fat, and/or fluid accumulation that may sometimes mask weight loss</strong></td>
<td></td>
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<tr>
<td>Height</td>
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<tr>
<td>Current weight (consider in context of dehydration or fluid accumulation if applicable)</td>
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<tr>
<td>Body mass index (BMI, calculated as weight in kilograms divided by height in meters squared) calculation and classifications26</td>
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</tr>
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<td>BMI &lt; 18.5, underweight</td>
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<td>BMI 18.5-24.9, normal</td>
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</tr>
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<td>BMI 25.0-29.9, overweight</td>
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<td>BMI 30.0-34.9, obesity class I</td>
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<td>BMI 35.0-39.9, obesity class II</td>
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<tr>
<td>BMI ≥ 40, obesity class III</td>
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<tr>
<td>Usual body weight (UBW)</td>
<td></td>
</tr>
<tr>
<td>% UBW = current weight/UBW x 100</td>
<td></td>
</tr>
<tr>
<td>Weight loss in context of time</td>
<td></td>
</tr>
<tr>
<td>If available and practical: body composition or percentage of body fat as measured by skinfold thickness, bioimpedance analysis, air displacement plethysmography, ultrasound, magnetic resonance imaging, computed tomography, and/or dual-energy x-ray absorptiometry22</td>
<td></td>
</tr>
<tr>
<td>Nutrition-focused physical examination: possible indications of malnutrition</td>
<td></td>
</tr>
<tr>
<td>Hair loss; dull, dry, brittle hair; loss of hair pigment</td>
<td></td>
</tr>
<tr>
<td>Loss of subcutaneous tissue; muscle wasting</td>
<td></td>
</tr>
<tr>
<td>Poor wound healing: pressure ulcer</td>
<td></td>
</tr>
<tr>
<td>Region surrounding the eye: dark circles, hollow look, depressions, loose skin</td>
<td></td>
</tr>
<tr>
<td>Upper part of arm: minimal space between skinfolds</td>
<td></td>
</tr>
<tr>
<td>Thoracic and lumbar regions: depressions between ribs apparent, iliac crest prominent</td>
<td></td>
</tr>
<tr>
<td>Assessment of edema (localized or generalized)</td>
<td></td>
</tr>
<tr>
<td><strong>Data to be collected for documenting diminished functional status</strong></td>
<td></td>
</tr>
<tr>
<td>Hand grip strength (not always practical in intensive care setting)</td>
<td></td>
</tr>
<tr>
<td>Ability to be weaned from mechanical ventilation</td>
<td></td>
</tr>
<tr>
<td>Ability to tolerate physical therapy</td>
<td></td>
</tr>
<tr>
<td>Ability to perform activities of daily living</td>
<td></td>
</tr>
<tr>
<td>General performance status</td>
<td></td>
</tr>
</tbody>
</table>

a Based on information from White et al15 and Malone and Hamilton.23
to be overt and laboratory values tend to be markedly abnormal. Mild to moderate inflammation is associated with chronic conditions and so can be more difficult to discern. Thus, a patient’s nutritional status and characteristics should be assessed in the context of the patient’s overall clinical situation. Any characteristics of malnutrition identified should be documented at baseline and at frequent intervals throughout the patient’s hospital stay. Tracking information collected at multiple times and trends in assessment data are more useful in determining nutritional status and the efficacy of intervention than are data from a single time.

<table>
<thead>
<tr>
<th>Clinical</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of acute or chronic clinical condition(s) associated with inflammatory response</td>
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<tr>
<td>Fever</td>
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</tr>
<tr>
<td>Presence of infection</td>
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</tr>
<tr>
<td>Urinary tract infection</td>
<td>Decreased platelet count</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>Decreased or increased white blood cell count</td>
</tr>
<tr>
<td>Sepsis</td>
<td>Marked negative nitrogen balance</td>
</tr>
<tr>
<td>Wound or incisional infection</td>
<td></td>
</tr>
</tbody>
</table>

* Based on information from White et al15 and Malone and Hamilton.23
information gathered during the nutritional assessment is the foundation for the nutritional intervention. Every member of the health care team should document pertinent information in the member’s chart notes. Effective recognition and management of malnutrition in the ICU requires education of nurses and physicians and reliable communication among members of the critical care team, including nursing, pharmacy, medical, and nutrition disciplines. The team approach ensures prompt recognition of malnutrition when a patient is admitted and swift collection of assessment data for early intervention and better patient outcomes.

Risk for Malnutrition in Obese Critically Ill Patients
An estimated 25% to 30% of patients admitted to an ICU have a body mass index (calculated as weight in kilograms divided by height in meters squared) greater than 30.\(^\text{25}\) Chronic obesity results in pathophysiological alterations in all major organ systems; the main derangements are in cardiovascular, respiratory, and metabolic functions.\(^\text{26}\) Many recent studies\(^\text{27-36}\) on morbidity and mortality rates of obese critically ill patients have indicated that although obesity may not have an effect on hospital mortality rates (and may even have a protective effect), obese patients tend to have increased hospital morbidity as evidenced by longer duration of mechanical ventilation, longer ICU length of stay, longer hospital length of stay, and increased rate of infection. Missed or delayed detection of malnutrition in these patients may contribute to these adverse outcomes.

Obesity is defined as having excess adipose tissue mass or fat mass for a given body weight. Compared with lean individuals, patients with extreme obesity have greater amounts of adipose tissues in all depots. When the adiposity is greater in the abdominal region, the risks for insulin resistance, hyperglycemia, metabolic syndrome, and associated complications in the ICU are increased. In addition, obese persons have increased levels of proinflammatory cytokines that cause chronic, mild to moderate inflammation and contribute to the signs and symptoms of metabolic syndrome, such as hyperglycemia.\(^\text{27}\)

Compared with lean persons, severely obese persons tend to have a relatively lower percentage of lean body mass.\(^\text{38}\) Because weight loss involves a loss of both fat mass and lean mass, unintended weight loss in obese persons results in a body composition that continues to have a lower percentage of lean mass, and this lower percentage contributes to reduced strength.\(^\text{39}\) Critically ill obese patients are at high risk for sarcopenic obesity, the type of malnutrition with chronic mild to moderate inflammation. Sarcopenic obesity is characterized by loss of muscle mass, with reduced physical function.\(^\text{22,38}\) Nutritional assessment based on body composition or percentage of body fat in obese ICU patients can help identify at-risk patients and guide optimal nutritional care. Current nutritional support guidelines for adult patients with obesity emphasize high-protein, hypocaloric feedings (assuming no renal or hepatic dysfunction), and provision of adequate nutrients for recovery and promotion of strength rather than weight loss.\(^\text{39,40}\) Better understanding of this type of chronic malnutrition will ensure timely identification and early nutritional intervention.

Comment
Regarding the case study, nursing care of patients who have had a stroke has many aspects, including ongoing neurological assessments and seizure precautions, blood pressure and neurological monitoring, screening for indications of dysphagia, promoting comfort and providing support to the patients and their family members, and providing adequate nutrition. Standardized order sets and critical paths are often used to guide the critical care team in determining the appropriate treatment plan. According to the information just presented and the data in Table 3, the patient had underlying chronic disease-related malnutrition, most likely characterized by sarcopenic obesity. Nutrition along with medical treatments such as thrombolytic therapy were critical for his recovery. Detection of malnutrition in this case was based on a clinical history of insufficient energy intake, unintended weight loss, compromised strength and functional status, and chronic inflammation. In documenting the patient’s malnutrition during nutrition assessment, the following diagnostic criteria with supporting evidence should have been included in his medical chart (specific data outlined in Table 3): insufficient energy intake, weight loss, loss of muscle mass, diminished functional status, and chronic inflammation.
The emphasis of nutritional intervention should be provision of adequate nutrients for helping recovery and promoting strength rather than weight loss. Recognizing the signs and symptoms of chronic disease-related malnutrition ensures early nutritional assessment and timely intervention.

**Discussion and Nursing Implications**

The new Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition guidelines for assessment of malnutrition in adults highlight the importance of inflammation in distinguishing the different types of malnutrition syndromes. The new guidelines and the information on the less readily recognized chronic disease-related malnutrition that could be manifested by obese critically ill patients are relevant to critical care nurses because the materials emphasize the key role of nurses in collecting information that will be used in nutritional assessment and in documentation of the rationale for the nutritional intervention plan. The frequency and intensity of contact of critical care nurses with critically ill patients place the nurses in a prime position to detect malnutrition. Keeping up with current guidelines promotes effective team communication, ensuring that at-risk patients receive timely nutritional support that will improve clinical outcomes.

A team approach to nutritional assessment is advocated to ensure the best quality of patient care.

**Acknowledgments**

The authors thank Ms Diana Paulson for her help during the preparation of the case study for this article.

**Financial Disclosures**

None reported.

**References**


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**Table 3** Case study data used in nutritional assessment to identify and document malnutrition related to chronic disease

<table>
<thead>
<tr>
<th>Category</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical state</td>
<td>Bowel sounds evidence of working gut with no gastrointestinal issues</td>
</tr>
<tr>
<td></td>
<td>Longstanding obesity and metabolic syndrome as evidenced by</td>
</tr>
<tr>
<td></td>
<td>Clinical history</td>
</tr>
<tr>
<td></td>
<td>BMI² = 37.0, obesity class II</td>
</tr>
<tr>
<td></td>
<td>Abdominal adiposity as evidenced by waist circumference</td>
</tr>
<tr>
<td></td>
<td>Laboratory values indicative of metabolic syndrome</td>
</tr>
<tr>
<td></td>
<td>Elevated levels of blood glucose and hemoglobin A₁, indicative of impaired</td>
</tr>
<tr>
<td></td>
<td>glucose metabolism/insulin resistance</td>
</tr>
<tr>
<td></td>
<td>Elevated blood pressure</td>
</tr>
<tr>
<td></td>
<td>Elevated fasting level of triglycerides</td>
</tr>
<tr>
<td>Data indicating inadequate energy intake</td>
<td>Poor appetite before admission</td>
</tr>
<tr>
<td></td>
<td>Typical 24-hour diet recall with patient and his wife revealed insufficient energy intake</td>
</tr>
<tr>
<td>Data indicating weight loss, loss of muscle mass, and/or loss of subcutaneous fat</td>
<td>% UBW = 94% UBW</td>
</tr>
<tr>
<td></td>
<td>Unintentional weight loss; % weight change = 6% weight loss</td>
</tr>
<tr>
<td></td>
<td>Body composition measurements could be used to confirm suspected loss of muscle mass</td>
</tr>
<tr>
<td>Data indicating diminished functional status</td>
<td>Functional impairment as evidenced by difficulty ambulating and loss of strength in preceding year per family report</td>
</tr>
<tr>
<td>Data indicating mild to moderate inflammation</td>
<td>Elevated serum level of C-reactive protein typical of inflammation associated with obesity</td>
</tr>
<tr>
<td></td>
<td>Elevated blood glucose level</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; UBW, usual body weight.

* Calculated as weight in kilograms divided by height in meters squared.
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New Guidelines for Assessment of Malnutrition in Adults: Obese Critically Ill Patients

**Facts**

Critical care patients tend to be at high risk for malnutrition and thus require a thorough nutritional assessment. Critical care nurses are in a prime position to screen patients at risk for malnutrition and to work with members of the interprofessional team in implementing nutritional intervention plans.

- Malnutrition in critically ill patients is associated with increased hospital morbidity and mortality, increased risk for infections, compromised immune status, poor wound healing, and extended hospital lengths of stay.
- The 3 etiology-based definitions of malnutrition in the new guidelines are starvation-related malnutrition without inflammation, chronic disease-related malnutrition with mild to moderate inflammation, and acute disease- or injury-related malnutrition with marked inflammation.
- A total of 2 or more of the following 6 characteristics are currently recommended for the diagnosis of malnutrition in adults: insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation that may sometimes mask weight loss, and diminished functional status (eg, as indicated by hand grip strength).
- After patients with nutritional risk have been identified, the presence or absence and degree of inflammation should be assessed to determine the type of malnutrition. The Table gives parameters that may be useful in assessing inflammation status.
- Compared with lean individuals, patients with extreme obesity have greater amounts of adipose tissues in all depots. When the adiposity is greater in the abdominal region, the risks for insulin resistance, hyperglycemia, metabolic syndrome, and associated complications in the intensive care unit are increased.
- Keeping up with current guidelines promotes effective team communication, ensuring that at-risk patients receive timely nutritional support that will improve clinical outcomes. A team approach to nutritional assessment ensures the best quality of patient care. CCN

### Table

**Clinical and laboratory information useful in assessing inflammation**

<table>
<thead>
<tr>
<th>Clinical</th>
<th>Laboratory</th>
</tr>
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<tbody>
<tr>
<td>Presence of acute or chronic clinical condition(s) associated with inflammatory response</td>
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</tr>
<tr>
<td>Wound or incisional infection</td>
<td></td>
</tr>
<tr>
<td>Abscess</td>
<td></td>
</tr>
</tbody>
</table>

*Based on information from White et al15 and Malone and Hamilton23 [see article for citation information].*
Compassion Satisfaction and Compassion Fatigue Among Critical Care Nurses

Tara L. Sacco, RN, MS, CCRN, AGCNS-BC, ACCNS-AG
Susan M. Ciurzynski, RN, MS, PhD, PNP
Megan Elizabeth Harvey, RN, BSN
Gail L. Ingersoll,† RN, EdD

BACKGROUND  Although critical care nurses gain satisfaction from providing compassionate care to patients and patients’ families, the nurses are also at risk for fatigue. The balance between satisfaction and fatigue is considered professional quality of life.

OBJECTIVES  To establish the prevalence of compassion satisfaction and compassion fatigue in adult, pediatric, and neonatal critical care nurses and to describe potential contributing demographic, unit, and organizational characteristics.

METHODS  In a cross-sectional design, nurses were surveyed by using a demographic questionnaire and the Professional Quality of Life Scale to measure levels of compassion fatigue and compassion satisfaction.

RESULTS  Nurses (n = 221) reported significant differences in compassion satisfaction and compassion fatigue on the basis of sex, age, educational level, unit, acuity, change in nursing management, and major systems change.

CONCLUSIONS  Understanding the elements of professional quality of life can have a positive effect on work environment. The relationship between professional quality of life and the standards for a healthy work environment requires further investigation. Once this relationship is fully understood, interventions to improve this balance can be developed and tested. (Critical Care Nurse. 2015;35[4]:32-44)

Nurses who work at the bedside of critically ill patients witness marked human suffering. The nurses provide compassionate care to patients who experience illnesses and events that are often sudden, disfiguring, and life threatening. Although nurses obtain professional satisfaction from their work, their repeated exposure to the aftermath of critical illness puts them at high risk for compassion fatigue, a phenomenon with signs and symptoms similar to those of posttraumatic stress disorder.1

CE Continuing Education

This article has been designated for CE credit. A closed-book, multiple-choice examination follows this article, which tests your knowledge of the following objectives:

1. Differentiate between compassion satisfaction and compassion fatigue
2. Identify factors that contribute to compassion fatigue
3. Discuss the relationship between compassion satisfaction and healthy work environments

†Deceased.
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This phenomenon, known as compassion fatigue, was first described by Joinson\(^2\) in 1992 as a type of burnout specific to caregivers who help trauma patients. Although in health care the term trauma generally refers to patients who sustain organ and tissue damage caused by blunt or penetrating injury,\(^3\) the American Psychiatric Association\(^{46,48}\) refers to a traumatic stressor as “any event (or events) that may cause or threaten death, serious injury, or sexual violence to an individual, a close family member, or a close friend.” Thus, patients with organ failure, stroke, sepsis, and other life-threatening illnesses also experience trauma. Of crucial importance, although patients are the primary persons affected by trauma, patients’ caregivers, including nurses and health care providers, may experience secondary effects related to the resulting anguish.\(^5\)

Initial research on the measurement of compassion fatigue in the helping professions was published by Figley\(^1\) and Stamm.\(^6\) In studies of the reasons employees remain in their role as caregivers despite high levels of compassion fatigue, findings indicated that the employees also gain a sense of compassion satisfaction, which is defined as the positive feelings derived from helping others through traumatic situations.\(^6,8\) The cumulative experience of both compassion fatigue and compassion satisfaction is described as professional quality of life (ProQOL).\(^9\) As conceptualized by Stamm,\(^6\) a sustainable ProQOL is achieved by maintaining a healthy balance between the positive and negative aspects of caring.

Compassion satisfaction is the sum of all the positive feelings a person derives from helping others. As stated earlier, compassion fatigue was first described as a form of burnout, which is defined as a cumulative state of frustration with a person’s work environment that develops over a long time. Burnout remains a component of compassion fatigue in this model. The second component of compassion fatigue, secondary traumatic stress, is a feeling of despair caused by the transfer of emotional distress from a victim to a caregiver that often develops suddenly. In the presence of secondary traumatic stress, the caregiver is empathizing with the victim.\(^9,11\) Although the elements of compassion fatigue are related, secondary traumatic stress is an effect of experiences with specific types of patients, whereas burnout is an effect of environmental stressors and is not unique to health care providers.\(^12\) According to the ProQOL model, a caregiver’s level of burnout and secondary traumatic stress contribute to his or her experience of compassion fatigue.\(^9,11\) Ideally, the balance between compassion fatigue and compassion satisfaction should be achieved in the workplace and beyond, emphasizing the importance of a positive work-life balance.\(^9,11\)

In 2005 the American Association of Critical-Care Nurses\(^13\) published 6 standards for establishing and maintaining a healthy work environment (HWE). These standards challenge health care leaders to critically evaluate the state of the environment and to provide clear, measurable methods for improving working conditions. Numerous studies\(^14-17\) have established that compared with nurses working in a less stressful environment, nurses working in overly stressful conditions are more prone to mental and physical exhaustion, causing more missed days of work and higher rates of attrition. In addition, patient satisfaction and, more important, patient safety, are directly linked to nurses’ job satisfaction.\(^11,18\) Thus, nurse leaders are compelled to evaluate and improve nurses’ work environment. This evaluation should include an assessment of environmental risk factors for compassion fatigue and resources available for staff who may manifest signs and symptoms of this phenomenon.\(^10,12,13\)

**Objectives and Purpose**

The prevalence of compassion fatigue and compassion satisfaction has been explored in many populations of caregivers, including social workers and emergency,
medical-surgical, cardiovascular, pediatric, oncology, and hospice nurses, but rarely in critical care nurses.18,20-27 The primary purpose of our study was to establish the prevalence of compassion satisfaction and compassion fatigue in adult, pediatric, and neonatal critical care nurses at a large Magnet-designated academic medical center in western New York State. A secondary purpose was to describe the demographic, unit, and organizational factors that may contribute to both compassion satisfaction and compassion fatigue in these nurses.

Methods
Participants and Setting
This cross-sectional study was conducted in a 739-bed tertiary care, academic medical center in late 2010. The sample population was drawn from all critical care nurses (registered nurses and licensed practical nurses) working in single-acuity units (intensive care patients only) and mixed-acuity units (intensive care patients, progressive care patients, and general care patients in the same unit). The 9 targeted units included 3 adult intensive care units (ICUs; medical, surgical, and cardiovascular), 3 adult mixed ICUs and progressive care units (PCUs; 1 medical and 2 surgical), 1 pediatric ICU, 1 pediatric mixed-acuity unit (ICU, PCU, and general care patients), and 1 neonatal ICU. Critical care nurses were invited to participate in the survey if they were 18 years or older and were employed full-time, part-time, or per diem in 1 of the 9 targeted units.

Instruments
A demographic questionnaire and the ProQOL, version 5, survey were used in the study.9 Permission to use the ProQOL instrument was granted via the website of the tool’s author. The ProQOL survey consists of 3 subscales (compassion satisfaction, burnout, and secondary traumatic stress) used to measure compassion satisfaction and compassion fatigue. Of the 3 subscales, 2 (burnout and secondary traumatic stress) are components of compassion fatigue, whereas compassion satisfaction is a stand-alone measure. Previous testing9 indicated acceptable levels of internal consistency reliability for each of the subscales; the Cronbach α was 0.88 for compassion satisfaction, 0.75 for burnout, and 0.81 for secondary traumatic stress. As recommended by Stamm,9 selected items from the instrument were individualized for application to the target audience of the study reported here. Specifically, the terms help and helper were replaced with the terms care for and caregiver, respectively. Also, the phrase trauma victims was replaced with patients and families. Additionally, the surveys were transcribed to an electronic platform for ease of distribution.

Procedures
The study was approved by the medical center’s institutional review board. The medical center’s nurse leaders and clinical research representatives granted permission for electronic distribution of the survey to critical care nurses who met the inclusion criteria. An invitation to participate with a link to the online survey was sent via institutional e-mail, with a reminder e-mail 2 weeks later. Nurses were assured that their responses would be anonymous and that no participant identifiers would be collected. Nurses were informed that participation was voluntary and that completion of the survey constituted their willingness to participate in the study. The embedded link directed participants to a separate website for completion of the survey, which included instructions to enroll in a password-protected online platform where the nurses could receive a certificate of completion redeemable for a $2.50 beverage coupon.

Data Analysis
Data were downloaded from the online survey platform into a spreadsheet and then uploaded and analyzed by using SPSS, version 17.0 (IBM SPSS). A nominal significance level (α ≤ .05) was established a priori. Nurse, unit, and organizational characteristics were described by using descriptive measures. Correlations with Cronbach α were used to examine the internal consistency reliability of the ProQOL scale in the sample. After reverse coding of selected items, raw data were converted to t scores as indicated in the ProQOL manual.9 The use of t scores produced a standardization of each subscale in which the scale mean equaled 50, with a standard deviation of 10. Analysis of variance with post hoc comparisons via the Scheffé test was used to compare mean scores for each subscale according to nurse, unit, and organizational characteristics. Standardized t scores
were also converted to categorical levels (low = 22 or less, average = 23-41, and high = 42 or more) according to Stamm’s scoring thresholds. Because of an inadvertent omission of 1 item on the secondary traumatic stress subscale (I find it difficult to separate my personal life from my life as a caregiver), the thresholds were algebraically modified to reflect the revised total items. Each categorical level subscale was then analyzed by using cross tabulations with $\chi^2$ values.

**Results**

The number of nurses who responded to the survey was 221 (38% participation rate); highest percentages were from the neonatal (30%) and pediatric (16%) ICUs. Demographic characteristics are presented in Table 1. Consistent with the nurse demographics of the hospital, the majority of the sample were female (94.6%) and had a bachelor’s degree (71.0%). The Cronbach $\alpha$ values for the 3 subscales of the ProQOL instrument used were 0.91 for compassion satisfaction, 0.45 for burnout, and 0.73 for secondary traumatic stress. Generally speaking, participants scored within the average range for all 3 ProQOL subscales; however, group and individual findings in the compassion satisfaction and compassion fatigue measures differed significantly.

**Compassion Satisfaction**

**Group Mean Compassion Satisfaction Score**

Comparison of nurse, unit, and organizational characteristics revealed significant group differences in mean compassion satisfaction for 4 variables: sex, age, unit acuity, and change in nursing management (Table 2). Compared with male nurses ($n = 11$), female nurses ($n = 199$) reported significantly higher compassion satisfaction scores: $F_{1,208} = 4.5; P = .04$. Additionally, differences in mean compassion satisfaction differed significantly according to nurses’ age: $F_{5,204} = 2.4; P = .04$. Post hoc comparisons revealed that nurses 40 to 49 years old had significantly lower compassion satisfaction ($P = .03$) than did nurses in other age groups. Mean compassion satisfaction also differed significantly according to unit acuity level: $F_{2,205} = 6.3; P = .002$. Post hoc comparisons revealed that nurses working on single-acuity units had significantly higher compassion satisfaction ($P = .007$) than did nurses working on mixed-acuity units. Finally, compared with nurses who had no change in nursing management in the preceding year, nurses who had a recent change in management had significantly lower mean compassion satisfaction scores: $F_{1,191} = 9.9; P = .002$.
Individual Levels (Low, Average, High) of Compassion Satisfaction

Comparison of nurse, unit, and organization characteristics revealed significant differences in levels of compassion satisfaction for 3 variables: education, age, and unit acuity (Figure 1). The relationship between level of compassion satisfaction and highest level of education completed was significant: \( \chi^2 (n = 205) = 16; P = .003 \). The overwhelming majority of the nurses within this sample reported average (57%) or high (43%) levels of compassion satisfaction. High levels of compassion satisfaction were more likely among nurses with an associate’s degree (56%) or a master’s degree (58%) than among nurses with a bachelor’s degree (38%). The relationship between level of compassion satisfaction and age was also significant: \( \chi^2 (n = 208) = 20.7; P = .002 \). That is, high levels of compassion satisfaction were more likely (73%) to be reported among nurses 50 years or older than among their younger colleagues (34%-42%). Additionally, a significant relationship existed between level of compassion satisfaction and unit acuity, \( \chi^2 (n = 199) = 6.4; P = .04 \). That is, high levels of compassion satisfaction were more likely to be reported by nurses working on single-acuity units (ie, caring solely for ICU patients; 56%) than by nurses working on mixed-acuity units (ie, caring for ICU, PCU, and general care patients; 35%).

Compassion Fatigue

Group Mean Compassion Fatigue Scores

Comparison of nurse, unit, and organization characteristics revealed significant group differences in mean compassion fatigue for 4 variables: age, unit acuity, management change, and major system or practice change (Table 3). For age groups, significant differences occurred in mean burnout scores (\( F_{5,201} = 3.2; P = .008 \)) and
secondary traumatic stress scores \( (F_{5,206} = 3.0; P = .01) \). Post hoc comparisons revealed that nurses 40 to 49 years old had significantly higher burnout \( (P = .002) \) and higher secondary traumatic stress \( (P = .01) \) than did nurses in other age groups. Nurses 20 to 29 years old also reported significantly higher levels of secondary traumatic stress \( (P = .04) \) than did their older colleagues, although the mean burnout scores for the younger nurses did not differ significantly from the scores of other nurses outside that age group. Additionally, significant differences were found between acuity levels for both burnout \( (F_{1,194} = 8.6; P = .004) \) and secondary traumatic stress \( (F_{1,199} = 6.2; P = .01) \). Post hoc comparisons revealed that nurses working on mixed-acuity units had significantly higher burnout \( (P = .004) \) and secondary traumatic stress \( (P = .01) \) than did nurses working on single-acuity units. Furthermore, nurses working on a unit with a change in nursing management in the preceding year reported significantly higher levels of burnout \( (F_{1,188} = 14.6; P < .001) \) than did nurses who worked on a unit without a recent management change. Finally, nurses working on a unit with a major system or practice change in the preceding year had significantly higher mean secondary traumatic stress scores \( (F_{1,171} = 5.6; P = .02) \).

### Table 3

Mean differences in compassion fatigue \( (n = 221) \)

| Variable | Burnout | | | | | | Secondary traumatic stress | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | \( t \) score, mean (SD) | n | \( P^{b} \) | | \( t \) score, mean (SD) | n | \( P^{b} \) | | | | |
| **Age, y** | | | | | | | | | | | |
| 20-29 | 50.0 (8.1) | 86 | | 51.2 (10.3) | 90 | .04 | | | | |
| 30-39 | 49.4 (10.9) | 39 | | 47.8 (7.8) | 39 | | | | | |
| 40-49 | 54.1 (12.7) | 43 | .002 | 53.1 (11.3) | 43 | .01 | | | | |
| 50+ | 45.7 (7.8) | 37 | | 45.8 (8.3) | 38 | | | | | |
| Missing | 16 | | | 11 | | | | | | |
| **Acuity level** | | | | | | | | | | | |
| Single | 48.2 (9.7) | 132 | .004 | 48.7 (10.4) | 135 | .01 | | | | |
| Mixed | 52.6 (9.9) | 64 | | 52.4 (8.9) | 66 | | | | | |
| Missing | 25 | | | 20 | | | | | | |
| **Nursing management change** | | | | | | | | | | | |
| Yes | 53.1 (10.7) | 93 | | 50.6 (10.5) | 94 | | | | | |
| No | 47.7 (8.7) | 97 | | 49.4 (10.0) | 100 | | | | | |
| Missing | 31 | | | 27 | | | | | | |
| **System/practice change** | | | | | | | | | | | |
| Redesign | 51.0 (10.1) | 75 | | 51.9 (10.8) | 74 | .02 | | | | |
| Yes | 49.0 (9.8) | 95 | | 48.3 (9.7) | 99 | | | | | |
| No | 51 | | | 48 | | | | | | |

\( ^{a} \) Missing indicates that response was left blank or respondent selected decline to answer. For acuity level, single indicates intensive care unit; mixed indicates intensive care unit/progressive care unit or intensive/progressive/general care unit.

\( ^{b} \) Significant according to Scheffé post hoc comparisons.

**Individual Levels (Low, Average, High) of Compassion Fatigue:** Comparison of nurse, unit, and organization characteristics revealed significant differences in levels of burnout for 3 variables: management change, unit, and unit acuity (Figure 2). The relationship between level of burnout and recent change in nursing management was significant: \( \chi^{2}_{2} (n = 190) = 9.0; P = .01 \). Low levels of burnout were more likely among nurses working on a unit without a recent change in nursing management (65%) than among nurses working on a unit with a management change (44%). Level of burnout was also significantly related to the unit on which the nurse was employed: \( \chi^{2}_{16} (n = 198) = 28.9; P = .02 \). In this sample of critical care nurses, the majority (57%) reported low levels of burnout. Unit differences are displayed in Figure 2. Further analysis revealed differences in burnout according to unit acuity: \( \chi^{2}_{2} (n = 196) = 8.9; P = .01 \). Low levels of burnout were reported by 64% of nurses working on single-acuity units and 42% of nurses working on mixed-acuity units. Similarly, more nurses from single-acuity units (81%) reported low levels of secondary traumatic stress than did nurses on mixed-acuity units (61%): \( \chi^{2}_{1} (n = 201) = 9.4; P = .002 \) (Figure 3). In addition to
unit acuity, level of secondary traumatic stress was significantly related to age: $\chi^2(n = 210) = 9.1; P = .03$. Within this sample, the overwhelming majority (74%) of the nurses reported low levels of secondary traumatic stress; the greatest percentage (87%) was among those 50 years or older.

**Discussion and Implications**

The primary aim of this study was to determine the prevalence of compassion satisfaction and compassion fatigue in critical care nurses in an academic medical center. After responses were correlated, with few exceptions, critical care nurses scored within the average range for all 3 subscales. Differences in scores between units were not significant. Therefore, the critical care nurses in this sample have an effective balance in their ProQOL. From an organizational perspective, this finding is positive because no single unit had a high degree of burnout or secondary traumatic stress. Thus, the current
work environment appears to foster a healthy balance, and work environment interventions can be directed to increasing levels of compassion satisfaction rather than to preventing compassion fatigue.

Of the individual demographic factors examined, few significantly affected the degree of compassion satisfaction, burnout, or secondary traumatic stress. The most striking finding suggests that the age of a nurse has a great impact on ProQOL. Nurses 50 years or older scored higher on the compassion satisfaction scale and lower on the burnout and secondary traumatic stress scales than did their younger counterparts. A possible conclusion is that older nurses have more professional and life experience and therefore are better prepared to cope with the challenges of critical care nursing. The relationship between age and ProQOL has been examined by other researchers. Burston and Stichler28 found a significant difference in compassion fatigue subscales according to age and nursing experience. Compassion fatigue was negatively correlated with knowledge and skill, whereas knowledge and skill were positively correlated with a nurse's age and experience. Thus, the older and more experienced the nurse, the higher was the degree of knowledge and skill and the lower was the risk for compassion fatigue.

The findings28 that younger and/or less experienced nurses are at higher risk for compassion fatigue than are their older colleagues is congruent with our findings. Young et al23 reported that the degree of burnout was higher on a heart and vascular ICU, which had a larger number of older nurses, than on the heart and vascular intermediate care unit, which had a larger number of younger nurses. These researchers23 concluded that younger nurses might not have been in the profession long enough for signs of burnout to develop. Finally, Potter et al25 examined the impact of experience on ProQOL. Staff nurses with 6 to 10 years of experience had higher burnout and lower compassion satisfaction scores than did nurses with less experience; nurses with 11 to 20 years of experience had the highest degree of compassion fatigue.25 Although the findings of these studies21,25,28 differ, collectively they indicate that differences in age and experience can affect ProQOL, and therefore further study is warranted to fully examine this relationship.

The relationship between highest educational degree and ProQOL scores also implies some differences. Smart et al23 suggested that increasing the number of nurses with a bachelor's degree in an institution increases the likelihood of improved patient outcomes and can decrease levels of compassion fatigue. In our study, nurses with a bachelor's degree reported lower compassion satisfaction scores than did nurses with associate's or master's degrees; no differences in secondary traumatic stress and burnout were related to educational preparation. One possible explanation is that nurses with bachelor's degrees were undergoing transition at the time of data collection, a finding consistent with the results of other studies.29,30 Further research is needed to examine the combined relationship of educational preparation and entry into practice. Implications for nurse educators may also be discovered by further investigation into the relationship between educational preparation and ProQOL. Coetzee and Klopper31 stated that nursing students should be educated about compassion fatigue as well as coping and self-care skills. Adding information about compassion fatigue to undergraduate nursing education may be warranted.

The difference in educational preparation and degree of compassion satisfaction is compelling in light of the current recommendation of the Institute of Medicine32 for an increase in the number of nurses with a bachelor's degree within the workforce to 80% by 2020. Achieving this goal would likely place many of these bachelor's prepared nurses in critical care areas. Although the addition of more nurses with a bachelor's degree is an important component for altering the current health care environment, further study is needed to examine the full extent of the differences in ProQOL scores among nurses with varied educational preparation.

Finally, significant differences according to sex were noted in the compassion satisfaction and secondary traumatic stress subscales. This finding must be interpreted with caution because of the small proportion of male participants (5%). Hooper et al33 also discovered a relationship between ProQOL scores and sex. In a sample of emergency, ICU, nephrology, and oncology nurses, females had higher compassion fatigue scores than did males.33 Similar to our sample, the sample in the study by Hooper et al also had a lower number of male participants (8.3%). Further study is warranted to fully understand sex-based differences as they relate to ProQOL.
Organizational, or system, factors that affect ProQOL in our sample included management change, unit acuity level, and major systems change. For the purposes of analysis, nursing management change was defined as either a change in nurse manager or nurse leader staff within the preceding year. Nurses who reported that their unit had a managerial change within the preceding year scored lower on the compassion satisfaction scale and higher on the burnout scale than did nurses who did not experience such change. This finding is important because it suggests that units with a stable leadership structure have an environment more supportive of compassion satisfaction. Our findings suggest that managerial change is a factor in the development of burnout within a unit and is a potential contributing factor. Therefore, efforts to retain qualified critical care nurses and nurse managers should be emphasized.

As stated earlier, the units included in our study are single- and mixed-acuity units. Nurses in the single-acuity units scored higher on the compassion satisfaction scale and lower on the burnout and secondary traumatic stress scales than did nurses in the mixed-acuity units. This finding is of interest because many of the mixed-acuity units are new to the medical center. The results suggest that challenges in caring for patients with varied acuity levels within the same unit differ from the challenges for nurses in a single-acuity unit. Young et al\textsuperscript{23} noted that different acuity levels can affect ProQOL. In a comparison of heart and vascular ICU and intermediate care nurses, the ICU nurses scored higher on the burnout subscale. Young et al\textsuperscript{23} proposed that higher acuity, mortality rates, and greater use of technology contributed to these differences. Although this finding is contrary to our results, it does point to a need for future investigation.

For the purposes of our study, a major system or practice change was defined as changes within the unit environment such as the opening or splitting of a unit (unit redesign) within the preceding year. Within that time frame, 3 of the 9 units had undergone unit redesign or were in the process of doing so. The respondents who experienced a systems or practice change scored higher on the secondary traumatic stress scale than did nurses who did not. Because change is a constant within the health care environment, this finding suggests that nurses are at higher risk for compassion fatigue as their work environment evolves. Nurse leaders would be smart to implement support systems to guide staff through these times of evolution.

Professional quality of life and the principles of an HWE are interrelated. The standards of an HWE\textsuperscript{13} can influence the degree to which an employee experiences compassion satisfaction and compassion fatigue. For instance, standard 1, skilled communication, focuses on promoting effective communication and multidisciplinary teamwork while eliminating intimidating behavior and mistrust. Such efforts can increase compassion satisfaction and decrease compassion fatigue. Increasing the degree of true collaboration will foster an increase in compassion satisfaction. Further, critical elements within standard 3, effective decision making, will decrease burnout and increase compassion satisfaction as nurses participate in shared governance. A lack of appropriate staffing has a direct link to burnout, whereas appropriate ratios and staffing mix have potential to increase compassion satisfaction. Developing a culture of meaningful recognition can directly influence the degree of compassion satisfaction. When a culture of meaningful recognition is not in place, nurses may feel undervalued, resulting in feelings of compassion fatigue. Finally, authentic leaders can influence compassion satisfaction and compassion fatigue directly. Effective leaders are integral to the development of an HWE; when the standard for authentic leadership is not met, the other standards are adversely affected.\textsuperscript{13} To improve the work environment, leaders should promote a culture of caring, recognition, professional development, and debriefing.\textsuperscript{10,18} Our findings can be used by organizational leaders to implement changes to improve the work environment. Although future research is needed to investigate the relationship between ProQOL and an HWE, we have identified characteristics that can be considered when changes are implemented. Nurse leaders are encouraged to refer to the ProQOL manual\textsuperscript{6} for suggestions to improve scores while also affecting the work environment.

Our findings have implications related to the nurses’ workforce within our facility and for transforming the work environment. In the months after our study, an institution-wide employee satisfaction survey was sent out. The findings of the survey were congruent with our results. Consequently, the leadership teams and shared governance councils of each unit have developed and
implemented action plans to address identified areas for improvement. The sustained effects of these efforts will be measured with subsequent employee satisfaction surveys.

Limitations

The generalizability of our findings may be limited. We focused on determining the prevalence of compassion satisfaction and compassion fatigue in a small sample of critical care nurses. Because of the cross-sectional design, the data could be representative of a bad day, high unit acuity, or any number of additional factors. A longitudinal design might be useful to determine a true reflection of ProQOL within a profession that experiences many fluctuations in day-to-day happenings. In addition, the findings related to the unacceptable reliability of the burnout scale and the low response rate should be interpreted with caution. In addition, the secondary traumatic stress scale had low reliability scores, which may be related to the omission of 1 subscale question and the change in the wording of item 28. Although many studies have indicated similar nurse and organizational differences in ProQOL, others had contradictory findings, particularly in relation to nurses’ age. A larger, multi-institutional study could be done to further explore these differences. Despite these limitations, our results highlight the importance of ProQOL measurement among critical care nurses and identifies areas for future research.

Conclusion

Understanding the principles and balance of ProQOL can have a positive effect on the work environment and, ultimately, outcomes of patient care. Nurse leaders can use ProQOL assessment and staff satisfaction scores to measure the effect of work environment interventions. Disseminating information about ProQOL to bedside nurses is particularly important because everyone has a role in improving the work environment. The link between ProQOL and an HWE, as well as workforce characteristics and organizational structures that affect ProQOL, require further confirmatory study to determine true significance. Once the relationships are fully understood, interventions to improve the balance between compassion satisfaction and compassion fatigue can be developed and tested. Critical care nurses most likely have fluctuating levels of compassion satisfaction and compassion fatigue, depending on the population of patients cared for and the nurses’ personal circumstances. The goal of interventions may be to modify the factors over which nurses do have influence. Providing nurses with an environment in which they are supported through difficult situations, given accolades for their work, and made to feel that their input is valued in removing or modifying system-based obstacles will remain vitally important.

Acknowledgments

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Financial Disclosures

None reported.

References


Facts

Although critical care nurses gain satisfaction from providing compassionate care to patients and patients’ families, the nurses are also at risk for fatigue. The balance between satisfaction and fatigue is considered professional quality of life.

A demographic questionnaire and the professional quality of life (ProQOL) survey were used in the study. The sample population was all critical care nurses working in single-acuity and mixed-acuity units.

Study Findings

• Female nurses reported significantly higher compassion satisfaction scores than did male nurses.
• Nurses 40 to 49 years old had significantly lower compassion satisfaction than did nurses in other age groups.
• Nurses working on single-acuity units had significantly higher compassion satisfaction than did nurses working on mixed-acuity units.
• Compared with nurses who had no change in nursing management in the preceding year, nurses who had a recent change in management had significantly lower mean compassion satisfaction scores.
• High levels of compassion satisfaction were more likely among nurses with an associate’s degree or a master’s degree than among nurses with a bachelor’s degree.
• Nurses 40 to 49 years old and nurses working on mixed-acuity units had significantly higher burnout and higher secondary traumatic stress than did nurses in other age groups and nurses working on single-acuity units, respectively.
• Nurses 50 years or older scored higher on the compassion satisfaction scale and lower on the burnout and secondary traumatic stress scales than did their younger counterparts. A possible conclusion is that older nurses have more professional and life experience and therefore are better prepared to cope with the challenges of critical care nursing.
• Our findings suggest that managerial change is a factor in the development of burnout within a unit and is a potential contributing factor.

Healthy Work Environment Standards

The standards of a healthy work environment can influence the degree to which a nurse experiences compassion satisfaction and compassion fatigue.

• Skilled communication focuses on promoting effective communication and multidisciplinary teamwork while eliminating intimidating behavior and mistrust.
• Increasing the degree of true collaboration will foster an increase in compassion satisfaction.
• A lack of appropriate staffing has a direct link to burnout, whereas appropriate ratios and staffing mix have potential to increase compassion satisfaction.
• Developing a culture of meaningful recognition can directly influence compassion satisfaction. When a culture of meaningful recognition is not in place, nurses may feel undervalued, resulting in compassion fatigue.
• Authentic leaders can influence compassion satisfaction and compassion fatigue directly. When the standard for authentic leadership is not met, the other standards are adversely affected.
• To improve the work environment, leaders should promote a culture of caring, recognition, professional development, and debriefing.
• Understanding the elements of professional quality of life can have a positive effect on work environment.
Learning objectives: 1. Differentiate between compassion satisfaction and compassion fatigue. 2. Identify factors that contribute to compassion fatigue. 3. Discuss the relationship between compassion satisfaction and healthy work environments.

1. According to this study, which of the following nurses has the lowest risk of developing compassion fatigue?
   a. New graduate nurse, age 50, works in a mixed acuity intensive care unit (ICU)
   b. Nurse, age 29, with 5 years experience, works in a single acuity ICU
   c. Nurse age 55, with 30 years experience, works in a single acuity ICU
   d. New graduate nurse, age 30, works in a single acuity ICU

2. According to this study, nurses with a bachelor’s degree are at higher risk for which of the following?
   a. Burnout and traumatic stress
   b. Compassion fatigue
   c. Compassion satisfaction
   d. The effect of education was inconclusive

3. Which of the following best describes the feeling of despair that is caused by transfer of emotional distress?
   a. Traumatic stress
   b. Secondary traumatic stress
   c. Includes environmental stress as well as patient care
   d. Is an emotional response based on a specific patient experience

4. With respect to compassion satisfaction and compassion fatigue, which of the following can nurse leaders do to improve the work environment?
   a. Decrease the nurse to patient ratio
   b. Cultivate a culture of caring and meaningful recognition
   c. Survey the nursing staff to determine their needs
   d. Recognize the role of each team member

5. Which of the following should be the primary goal of employee satisfaction surveys?
   a. Allow employees to vent their concerns
   b. Address areas for improvement
   c. Reduce compassion fatigue
   d. Promote system change

6. Which of the following is an important outcome in maintaining a positive work-life balance?
   a. Compassion satisfaction
   b. Healthy work environment
   c. Personal satisfaction
   d. Patient safety

7. Nursing staff contribute to a healthy work environment by which of the following?
   a. Recognizing their response to a stressful situation
   b. Participating in a shared governance
   c. Implementing system change in care delivery
   d. Tolerating inappropriate behaviors in a stressful environment

8. Which of the following best describes how secondary traumatic stress differs from burnout?
   a. Affects all professions regardless of job category
   b. Affects only health care providers working with trauma victims
   c. Includes environmental stress as well as patient care
   d. Is an emotional response based on a specific patient experience

9. Standards of a healthy work environment that directly influence compassion satisfaction and compassion fatigue include which of the following?
   a. Multidisciplinary teamwork
   b. Creating a culture of meaningful recognition
   c. Changes in the work environment
   d. Changes in management

10. The ProQOL survey used in this study measured with of the following?
    a. Compassion satisfaction and compassion fatigue
    b. Compassion satisfaction and healthy work environment
    c. Burnout and secondary traumatic stress
    d. Patient safety and healthy work environment

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

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The American Association of Critical-Care Nurses is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center’s Commission on Accreditation. AACN has been approved as a provider of continuing education in nursing by the State Boards of Nursing of California (#003063) and Louisiana (#ABN12). AACN programming meets the standards for most other states requiring mandatory continuing education credit for relicensure.
Patient safety organizations and health care accreditation agencies recognize the significance of clinical alarm hazards. The Association for the Advancement of Medical Instrumentation, a nonprofit organization focused on development and use of safe and effective medical equipment, identifies alarm management as a major issue for health care organizations. ECRI Institute, a nonprofit organization that researches approaches for improving patient safety and quality of care, identifies alarm hazards as the most significant of the “Top Ten Health Technology Hazards” for 2014. A new Joint Commission National Patient Safety Goal focusing on clinical alarm safety contains new requirements for accredited hospitals to be fully implemented by 2016. Through a fictional unfolding case study, this article reviews selected contributing factors to clinical alarm hazards present in inpatient, high-acuity settings. Understanding these factors improves contributions by nurses to clinical alarm safety practice. (Critical Care Nurse. 2015;35[4]:45-57)

Patient safety organizations and health care accreditation agencies recognize the significance of clinical alarm hazards. The Association for the Advancement of Medical Instrumentation, a nonprofit organization focused on development and use of safe and effective medical equipment, identifies alarm management as a major issue for health care organizations.1 ECRI Institute, a nonprofit organization that researches approaches for improving patient safety and quality of care, identifies alarm hazards as the most significant of the “Top Ten Health Technology Hazards” for 2014.3 In 2013, The Joint Commission (TJC) published a Sentinel Event Alert4 and proposed a National Patient Safety Goal (NPSG) (see sidebar) focusing on medical device alarm safety.5 Complete implementation of the NPSG is anticipated by 2016.

With the ongoing emphasis on alarm safety, it is imperative that progressive and critical care nurses appreciate the impact of alarm-related hazards and the scope of contributing factors. Such an appreciation enables meaningful participation in NPSG 06.01.01 compliance, including required assessments and implementation of corrective strategies. Through a fictional unfolding case study (based on published events), this article illustrates selected contributing factors from the perspective of nurses. A glossary (Table 1) defines key alarm-related terms (identified in italics where first mentioned in the text).6-9 Of note, there is a lack of consensus on alarm-related terminology; the glossary was developed on the basis of a review of definitions published by leading authorities and evidence.
Impact of Alarm Hazards in Health Care

The true impact of alarm hazards in health care is unknown. Although at least 4 major reviews of suspected alarm-related deaths have been completed since 2002, investigators emphasize that the true incidence of alarm-related events and related trends are difficult to determine. Regardless of these difficulties, the hazard is well recognized. As stated by the Institute of Safe Medication Practices, “awareness of the problem is not an issue—the absence of meaningful action is.”

Common Perceptions About Alarms

Knowledge deficits and misperceptions about alarms exist among clinicians, hospital leaders, and laypersons. Mainstream media and patient safety literature contain language with the potential to be misconstrued or oversimplify alarm hazards. Nurses (and other device users) have been described as “overwhelmed,” “complacent,” “negligent,” and “apathetic” providers who “ignore” alarms and “abandon” patients. In addition, *alarm fatigue* is often identified as the cause of an alarm-related event, without acknowledgment of additional related factors (eg, device design).

Understanding Alarm-Related Events: A Team Effort

Every alarm-related event (and potential alarm-related event) exists within a unique set of interrelated variables, which may include organizational culture, device audibility, user characteristics, and unit layout. Organizations often fail to consider these and other key contributors to alarm safety. This article addresses several selected contributing factors. Table 2 contains additional examples, contributing factors, and associated strategies for improving safety. The case study illustrates several selected contributing factors, and the importance of interdisciplinary teamwork during the event review.

Alarms and Alerts in the Clinical Setting

A 68-year-old patient, admitted after esophageal stricture dilation, is found unconscious and apneic in his bed. He sustains a severe anoxic brain injury and dies after his family withdraws life-sustaining treatment. In a report to the patient safety department, a registered nurse writes, “the monitors did not alarm, which delayed initiation of resuscitation.” As required by TJC, leadership initiates a review of the event from a systems perspective (ie, a root cause analysis [RCA]). Jackie, a nurse from the unit, participates in the RCA. During the first meeting, she talks about the unit: “I’ve worked on this unit for 16 years. Over the past few years, the patients have become sicker, and it’s now a constant bombardment of alarms, beeps, and jingles. It can feel overwhelming, especially when the unit is busy. When I’m trying to get work done, I think sometimes I just block out the noise.”

Jackie’s description of clinical alarms in her unit resonates with most nurses; a walk through a progressive or critical care unit reveals an array of devices with alarms.

SIDEBAR

**National Patient Safety Goal 06.01.01 “Improve the safety of clinical alarm systems”**

The Joint Commission’s National Patient Safety Goal (NPSG) 06.01.01, “Improve the safety of clinical alarm systems,” contains 2 phases. The first phase, to be implemented by July 2014, requires accredited hospitals to establish alarms as an organizational priority, and to identify the most important alarms through a comprehensive risk assessment. Phase II, to be implemented by January 2016, compels accredited hospitals to implement policies and procedures containing specific elements related to alarm safety (eg, who can set, change, or discontinue monitoring).

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Table 1  Glossary of alarm-related terms

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<th>Term</th>
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<tr>
<td>Alarm</td>
<td>A device that signals a deviation from a predetermined “normal” status.</td>
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<td>Alarm escalation plan</td>
<td>Written guidance that defines (1) which caregivers receive initial alarm notification, (2) who receives secondary (and subsequent) notifications if an alarm is not initially responded to in a specific period of time, and (3) when each notification occurs. For example, 1 publication outlines the following plan: If a critical alarm sounds, the patient’s primary nurse is notified. If the primary nurse does not acknowledge the notification within 20 seconds (eg, by suspending alarm at the point of care), a predesignated back-up nurse is notified. If this follow-up notification is not acknowledged within 60 seconds, the charge nurse is notified.</td>
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<td>Alarm fatigue</td>
<td>A situation wherein people become desensitized to alarms in response to excessive exposure. The constant state of readiness that is generated by persistent alarms and alerts results in the lowering of one’s attention threshold, reducing the urgency of response.</td>
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<td>Alarm inventory</td>
<td>Comprehensive list of the devices in an organization that generate alarms; an accurate alarm inventory is essential for effective alarm management.</td>
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<tr>
<td>Alarm management</td>
<td>Comprehensive approach to mitigating alarm-related hazards, improving alarm response, and ensuring prompt and effective alarm verification. Integrates organizational and unit culture, data from organizational alarm inventory, policy, procedures, and management strategies.</td>
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<tr>
<td>Alarm signal</td>
<td>The notification of presence of a monitored condition or deviation from normal status. Clinical alarms traditionally employ acoustic and/or visual signals, but integration of vibrotactile cues (eg, vibration) is increasing.</td>
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<tr>
<td>Alert</td>
<td>Advisory systems that do not inherently require immediate response or awareness; for example, the single tone emitted at the completion of a secondary infusion is an alert.</td>
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<tr>
<td>Device alarm</td>
<td>Alarm designed to indicate equipment malfunction or variation from a normal device condition. A variety of medical devices, from life-sustaining equipment to less critical equipment (eg, hand-held thermometers), incorporate device alarms. For example, the “air in line” message that is activated during an intravenous infusion due to the presence of bubbles in the fluid stream is a device alarm. These are also known as technical alarms.</td>
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<td>False alarm</td>
<td>An alarm generated that indicates the presence of a physiological event when no true event has occurred. See false-negative and false-positive alarms.</td>
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<td>False-negative alarm</td>
<td>Absence of an alarm when a valid triggering event is present. A false negative may occur when signal acquisition technology does not detect an arrhythmia; for example, when a patient is asystolic but no alarm sounds. A false-negative alarm may also be referred to as a “true alarm missed” or simply, “a miss.”</td>
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<td>False-positive alarm</td>
<td>A technically incorrect alarm that indicates that a given condition has been fulfilled, when in fact the triggering condition is not present; for example, a ventricular tachycardia alarm activated by the use of an electric toothbrush.</td>
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<td>High sensitivity</td>
<td>Highly sensitive alarm systems are designed to ensure a low incidence of false-negative alarms by detecting signals and generating alarms for events that may be significant, but may also be artifact.</td>
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<td>Low specificity</td>
<td>Specificity refers to the ability of a system to correctly exclude a condition. Low-specificity systems are characterized by higher numbers of false-positive alarms than high-specificity systems.</td>
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<td>Nuisance alarm</td>
<td>Also known as nonactionable alarms, these are technically correct alarms that have no clinical significance; for example, a high-pressure alarm on a ventilator triggered by an isolated cough and requiring no clinical response or corrective action may be a nuisance alarm.</td>
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<td>Physiological alarm</td>
<td>Integrated into systems that monitor individual or aggregate biological parameters, these signals occur when the monitored variable(s) fall outside of a predetermined limit or pattern; for example, a physiological alarm may occur for tachycardia, bradycardia, or upon recognition of asystole.</td>
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<tr>
<td>Point-of-care alarm</td>
<td>Devices that enable communication of alarm signals at the patient’s bedside.</td>
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* These definitions are adapted from multiple sources and are based on the best available evidence. Interdisciplinary consensus does not exist for many alarm-related terms.
### Table 2: Examples of alarm-related events, potential contributing factors, and strategies for reducing likelihood of alarm-related events

<table>
<thead>
<tr>
<th>Alarm-related event (adapted from published reports)</th>
<th>Potential contributing factors (based on factors for similar events)</th>
<th>Strategies for reducing likelihood of alarm-related events</th>
</tr>
</thead>
<tbody>
<tr>
<td>A life-threatening arrhythmia occurs, yet neither an audio nor a visual physiological alarm is activated because the dysrhythmia processing function on the monitoring system has been turned off by a user.(^1)</td>
<td><strong>Device design</strong> User could easily turn off dysrhythmia processing function</td>
<td>Provide quick-glance, user-centric reference guides</td>
</tr>
<tr>
<td><strong>Organization/management</strong> User not aware that the dysrhythmia processing function could be disabled</td>
<td><strong>Organization/management</strong> User not aware that the dysrhythmia processing function could be disabled</td>
<td>Require initial orientation to devices for all staff, including contingency staff Establish periodic refreshers on medical devices, including advanced functions Validate users’ competencies in a standardized manner</td>
</tr>
<tr>
<td>A patient is admitted with chest pain and shortness of breath. Shortly after admission, the “leads off” alert sounds. When a nurse checks on the patient more than 1 hour later, he is unresponsive.(^1)</td>
<td><strong>Patient characteristics</strong> Diaphoretic and/or hairy patient whose leads continuously detach</td>
<td>Standardize unit practices for electrode and lead inspection and replacement (refer to AACN practice alert referenced in Table 3) Standardize skin preparation at the electrode site, including hair removal (refer to the AACN Practice Alert) Ensure ample supply of needed equipment, reducing disincentive to postpone electrode and lead changes</td>
</tr>
<tr>
<td><strong>Equipment characteristics</strong> Poor quality, inexpensive leads and/or electrodes contribute to frequent detachment of leads</td>
<td><strong>Equipment characteristics</strong> Poor quality, inexpensive leads and/or electrodes contribute to frequent detachment of leads</td>
<td>Purchase high-quality leads and electrodes</td>
</tr>
<tr>
<td>Frequent cough triggers a high-pressure alarm. Nurse changes the pressure limit to a very high limit to reduce the number of true-positive nuisance alarms. Occlusion of airway not detected.(^2)</td>
<td><strong>User characteristics</strong> Owing to high number of false alarms and nuisance alarms on the unit, the nurse experiences distress and takes an unsafe action in an attempt to reduce the number of alarm signals</td>
<td>Review unit-level data about false-positive and true-positive but “nuisance” alarms to guide unit-specific interventions for reducing the number of clinically insignificant alarms</td>
</tr>
<tr>
<td><strong>Device design</strong> Device permits the high-pressure alarm to be set to unsafe levels Signal acquisition and interpretation not sophisticated enough to differentiate between an intermittent peak airway pressure from a cough, versus a prolonged occlusion from a mucus plug or malposition of patient</td>
<td><strong>Device design</strong> Device permits the high-pressure alarm to be set to unsafe levels Signal acquisition and interpretation not sophisticated enough to differentiate between an intermittent peak airway pressure from a cough, versus a prolonged occlusion from a mucus plug or malposition of patient</td>
<td>Identify device-specific risks before and after implementation • Actively participate in critical assessment of devices</td>
</tr>
<tr>
<td>A provider turns off the audible alarm signal on a physiological monitor during a procedure to reduce distractions. The patient experiences an undetected respiratory event, because the alarm is not audible to providers.(^2)</td>
<td><strong>Device design</strong> Device user is unable to easily detect that the monitor is in an unsafe mode (ie, cannot readily tell by looking at the display that the audio alarm has been turned to “off,” status icons not intuitive) Device permits audible alarms to be turned off for extended periods</td>
<td>Identify device-specific risks before and after implementation • Actively participate in critical assessment of devices</td>
</tr>
<tr>
<td>A ventilator becomes disconnected, but the alarm volume had been turned down during the previous procedure and had not been reset.(^2)</td>
<td><strong>Device design</strong> Device settings did not automatically default to safe settings (potentially unsafe settings could be retained, and could be undetected)</td>
<td>Identify device-specific risks before and after implementation • Actively participate in critical assessment of devices</td>
</tr>
<tr>
<td><strong>User characteristics</strong> Initial user lacked clinical alarm management skills and turned down the alarm volume instead of modifying parameters to reflect the clinical situation</td>
<td><strong>User characteristics</strong> Initial user lacked clinical alarm management skills and turned down the alarm volume instead of modifying parameters to reflect the clinical situation</td>
<td>Explicitly train users to actively manage alarms within the system, not just rely on intrinsically acquired skills—this is a skill, like organization or leadership—“response to high risk areas,” not just training re: individual devices • Webinars and other educational tools are available from multiple organizations</td>
</tr>
</tbody>
</table>

Continued
In the most basic terms, an \textit{alarm} is intended to call attention to a deviation from a predetermined “normal” status. Response to a clinical \textit{alarm signal} requires (1) noting its presence, (2) identification of the source, (3) interpretation of the meaning within context, and (4) response.\^{13,27} There are 2 main types of clinical alarms (\textit{device alarms} and \textit{physiological alarms}). \textit{Alerts}, which differ from alarms, also contribute to noise in clinical settings. In some cases, when alerts are not addressed, a life-threatening situation may develop. For example, patients have reportedly been found unresponsive or dead after failures to respond to the “low battery” or “leads off” alerts generated by remote telemetry monitoring equipment.\^{23,28,29}

### A Multitude of Alarms: Everything Makes Noise

The number of devices that alarm continues to increase from “up to 6” in 1983, to 40 or more devices in 2012.\^{26} Increasing complexity of patients’ conditions and the introduction of more critically ill patients into intensive care units (ICUs) contributes to the increasing number of alarms in settings outside intensive care units (ICUs).\^{21,25} \textit{Point-of-care and direct notification alarm systems}, and personal technology belonging to health care workers, patients, and their visitors also contribute to the overall noise profile of a unit.

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**Table 2 Continued**

<table>
<thead>
<tr>
<th>Alarm-related event\textsuperscript{a} (adapted from published reports)</th>
<th>Potential contributing factors (based on factors for similar events)</th>
<th>Strategies for reducing likelihood of alarm-related events</th>
</tr>
</thead>
<tbody>
<tr>
<td>A patient experiences a prolonged period of prolonged decreased oxygen saturation that is undetected because the pulse oximetry oxygen saturation alarm parameter had been set to alarm at &lt;79%.</td>
<td>Policies and procedures: Nurse did not verify appropriate alarm parameters when assuming care of the patient</td>
<td>Establish practices wherein the nurse caring for the patient verifies that alarm parameters are appropriate for the clinical context. Address in policy who may change alarm parameters, and under what circumstances.</td>
</tr>
<tr>
<td>A telemetry monitoring system alerts “low battery” for more than an hour, but no one responds to the alerts. The telemetry box stops transmitting data, and the patient is later found unresponsive.\textsuperscript{23}</td>
<td>Policies and procedures: Absence of clear guidance about responsibility and expectations about how promptly to respond to low criticality device alerts, leading providers to assume that someone else would address the alert.</td>
<td>Change telemetry monitor box batteries at regular intervals (eg, daily) to prevent low-battery alerts.</td>
</tr>
<tr>
<td>A nurse leaves the clinic unit for a scheduled break, inadvertently leaving her pager on a patient’s bedside table. A physiological alarm sounds at the central nursing station, but no one responds to the event.\textsuperscript{24}</td>
<td>Environments: Physical characteristics of the unit prevent other providers from hearing a critical alarm signal.</td>
<td>Review unit-level data about false-positive, and true-positive but nuisance alarms to guide unit-specific interventions for reducing clinically insignificant alarms.</td>
</tr>
<tr>
<td></td>
<td>Communication: Unit lacked a standardized practice for handovers from one nurse to another when one nurse was planning to be off the unit.</td>
<td>If appropriate, preassign coverage and establish a standardized practice for handover whenever a nurse is leaving the unit.</td>
</tr>
<tr>
<td></td>
<td>Policy and procedure: Unit lacked a process to ensure response to unanswered alarms and everyone assumed that someone else would respond to the alarms and/or assumed that the nurse had received a page about the critical alarm.</td>
<td>Ensure escalation plan is established and enforced. Identify clear expectations about response to alarms, including second- and third-line responses.</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Events may be combined or slightly altered to clearly illustrate the contributing factor, possible solutions, or both.
The Wall of Sound: The Frequency of Alarm Signals

The sheer number of alarm signals in hospital settings is overwhelming and increasing. Work groups identify more than 600 alarms per ICU patient bed per day. Extrapolating data about alarm signals, TJC reports hundreds per patient per day, thousands per unit per day, and tens of thousands per hospital per day. Multiple factors contribute to the number of alarm signals, including the following:

- Redundant alarms on a single unit (eg, repeaters, satellite alarm stations, direct notification, and point-of-care systems). Although intended to improve safety and overall response to alarms, these systems can unintentionally increase noise (and risk) unless implemented deliberately.
- Generation of multiple signals by multiple systems in response to a single event (eg, a ventilator and a central monitor may both alarm in response to apnea, creating 2 separate alarms for 1 event). This may occur when alarm systems and devices are not fully integrated.
- Monitoring of patients without clinical indication or necessity (ie, overmonitoring) contributes significantly to excess alarms. This overmonitoring occurs in ICUs, cardiac care units, and step-down units.

Based on their understanding of the factors contributing to alarm hazards, the RCA team interviews additional staff from the unit.

Pamela, a nurse, was watching the central telemetry monitors that evening: "I was the nurse caring for the patient until 7 pm, and then I signed out to Susan. After signing out, I took over watching the monitors because the telemetry technician called out sick. The patient’s SpO2 [peripheral oxygen saturation] was set to alarm for [a saturation of] less than 86%. Occasionally it would drop to 85% if he took off his BiPAP [bi-level positive airway pressure] mask. When the patient heard the point-of-care alarm in his own room, he knew to replace his mask, and the alarming would stop. When he kept his mask on, his SpO2 was 99% to 100%. After 7 pm, he was more active, and this [activity] started generating lots of false alarms. I was interpreting rhythm strips for other patients, and I couldn’t concentrate. I suspended his SpO2 at the central station, which should have kept it from alarming for 5 minutes. What I don’t understand is why the central monitors didn’t pick up his changing heart rate as he was becoming hypoxic? That alarm should have gone off. I’m really concerned that the alarm system failed to work properly.”

Clinically Insignificant and False Alarms

Ideally, all alarms in clinical settings should be “actionable and clinically significant.” Actionable alarms are those that require timely intervention. In reality, only a small percentage of clinical alarms signal life-threatening or urgent conditions (eg, ventricular tachycardia) that require a clinical response. Research suggests that 80% to 99% of clinical alarm signals are either clinically insignificant or false alarms (false-positive or false-negative). These false alarms, combined with device alarms, comprise “the most significant sources of excessive alarms” in clinical settings. It is important to distinguish between the 2 types of false alarms during event analysis in order to identify appropriate actions. Technically incorrect (or false-positive) alarms are largely a function of emphasis on high sensitivity and low specificity during system design. In the immediacy, these alarms have limited clinical consequence for the individual patient; however, they contribute to alarm fatigue. False-negative alarms are rare but feared because they offer no opportunity for clinical intervention (eg, a monitored patient is in asystole, no alarm sounds, and the patient is found dead). Nuisance alarms also contribute significantly to the alarm profile of a unit. They frequently result from overly “tight” parameters, generating excessive true-positive but clinically insignificant alarms.

Correct terminology is critical when communicating with others about alarm safety and when addressing required standards for accreditation in NPSG 06.01.01. Because alarm management strategies differ depending on the specific type of alarms needing reduction (Table 2), inconsistent use of terms and/or disagreement about definitions can result in frustration, confusion, and poorly developed corrective actions. In the case study, the following types of alarms were described by the nurse who was observing the monitors:

- False-positive alarms: Patient movement triggers artifact-related alarms.
- (Possible) false-negative alarms: No alarm was heard for hypoxemia-induced bradycardia.
- True-positive, but clinically insignificant, alarms: Intermittent removal of the BiPAP mask triggers
the $\text{SpO}_2$ alarm, but the alarm ceases when the patient self-correction occurs.

The frequency of false and nuisance alarms directly affects perception of alarm reliability and influences an individual’s response. An alarm perceived as 10% reliable generates a 10% response rate, and an alarm perceived to be 90% reliable generates a 90% response rate. As a result, excessive false and clinically irrelevant alarms increase alarm-related risks in a given clinical setting.

**Selected Responses to Alarms: Waiting for Self-Correction, Reducing Distress, and Desensitization**

In the case study, the nurses demonstrate common behavioral and cognitive responses to excessive alarms, including waiting for an alarm to self-correct, taking steps to reduce alarm-induced distress, and desensitization to alarms. Each of these responses may generate unintended risks for patients. Initially the nurse who is watching the monitors waits for the patient to resecure his BiPAP mask, self-correcting the alarm. Self-correction may occur when the patient or the patient’s family knowingly or unknowingly takes an action to correct the abnormal circumstance (eg, repositioning of arm to permit an intravenous infusion), or because the event causing an alarm is limited in duration (eg, a cough). Waiting for self-correction is a response based on the inherent tendency of humans to limit extraneous and unnecessary expenditure of cognitive or physical energy. Because of the high prevalence of false and clinically insignificant alarms in many settings, waiting for self-correction is subconsciously perceived as an efficient way to prevent task interruption.

The second response that the nurse demonstrates is an attempt to reduce distress by temporarily suspending the alarm from the central station. Units with incessant alarms have been described as “hostile” to patients, clinicians, and nonclinical workers alike. Any environment with frequent, persistent alarms generates frustration, irritation, and other distressing feelings, which can lead to burnout. In response to distress, humans take actions (consciously or unconsciously) to reduce or eliminate their negative feelings. These include modifying alarm parameters or silencing, suspending, or disabling alarms and can result in unheard true-positive alarms, or false-negative alarms.

The nurse participating in the RCA mentions that sometimes she does not hear the alarms. In areas with relentless alarms, alarm fatigue, or desensitization, develops. Over time, the excessive noise desensitizes those exposed to the alarms to the point where they unconsciously block out alarm signals, no longer aware of hearing or seeing signals. Concerned by the possibility of monitoring system malfunction, the biomedical engineer reviews the logs from the devices involved. She also reviews the monitoring system manual, which states that selecting “suspend” from the central station disables audible physiology alarms (but not visual alarms) at the central station. Alarms at the bedside remain activated. The suspension of alarms persists until action is taken to reactivate central alarms. In addition, the suspend function responds differently if activated at the point of care. When this is done, the bedside alarm signal(s) activated at that moment will cease to sound locally for 5 minutes, but central station alarms continue. In this specific clinical case, the nurse believed that she had suspended only the $\text{SpO}_2$ alarm function for a limited time, when in fact she suspended it and the other audible alarms for the selected patient indefinitely. The engineer confirms that a visual icon flashed on the central monitor, but it was apparently not seen by the monitoring nurse.

**Hazard Ahead! The User-Device Interface and Alarm Systems**

The device-user interface is critical. The nurse in the case study did not realize that suspending the alarms at the central station produced a different outcome than if she had suspended the alarm at the point of care. Physiological monitoring systems, like many other medical devices, are highly complex. Retrospective analysis of alarm-related events (and proactive assessments) demonstrates that users are often unaware of the intricacies of monitoring systems. In addition, users underestimate their knowledge gaps. Initial orientation to these systems and other devices are rarely sufficient to build strong skills and expertise with complex devices. Even confident, experienced users need ongoing education about medical devices. Informal or ad hoc orientation of new or contingency staff is also not adequate to ensure safe use. In the scenario just described, the nurse may have been unaware of (eg, had not been taught or
may have forgotten) the difference between locally and centrally suspending an alarm. The lack of user-friendly reference material exacerbates device complexity. Manuals for health devices are rarely designed with the end user in mind; they are lengthy and highly technical.8,13,26 Quick reference guides for clinician users have been well received in several settings.23

Settings: Suspended, Disabled, or Silenced?

In a TJC review of 98 sentinel alarm-related events, 37% involved alarms turned off inappropriately.4 Excessive alarms may prompt users to deliberately change settings, but other scenarios involve inadvertent, unintentional disabling of critical alarms (Table 2). Ideally, it should be difficult (if not impossible) to set parameters to unsafe settings (eg, an apnea alarm allowing a respiratory pause for more than 1 minute).55 Furthermore, system status should be readily displayed and easy to interpret, allowing users to detect unsafe settings quickly.55 In the event described, the consequence of suspending the alarm(s) from the central monitor was not obvious to the user.

The RCA team meets with Susan, the nurse caring for the patient when the event occurred: "I went into his room early in my shift; he was comfortable and tolerating his BiPAP. The unit was loud and he asked me to close the door. I let him know I'd be back shortly, and then I went to perform a dressing change. About 15 minutes later, I went back to his room. As I came down the hall, I heard the BiPAP machine alarming. When I opened the door, I could also hear the bedside [saturation] alarm. He was cyanotic and apneic.”

Environmental Factors Contributing to Alarm Hazards

Most alarm-related sentinel events occur in telemetry, ICU, “general medicine,” and emergency departments.4 The TJC review of sentinel alarm-related events states that, "alarm signals not audible in all areas" was a contributing factor in 26% of such events.4 Physical unit layout (eg, wall and corridor placement, spatial relationships between workstations and alarms) influences noise transmission. ICUs and other high-acuity environments are rarely designed "logically or properly," and little attempt is made to mitigate the limited ability of providers to respond to alarms and alerts.51 In addition, strategies for improving energy efficiency, noise reduction, and patients’ privacy (eg, soft wall coverings) can reduce clinical alarm safety. Ambient noise (eg, ventilation and air conditioning systems), and incidental noise (eg, floor cleaning) further limit alarm detection. As a result of environmental factors, alarms may be muted, muffled, and/or difficult to physically locate. Credible evaluation of alarm-related events requires understanding of the real-life conditions on a unit and how those conditions may vary.

Matt, the unit charge nurse, is also interviewed: "I was going to our stockroom to check inventory, and I heard a feeding pump beeping. When I came out, I could still hear it. I had to take an urgent report, but I text-paged both Susan and the other nurse working on that part of the unit. I texted “tube feed beeping in your room?” I now realize I heard the BiPAP. It honestly did not sound like a critical alarm.

Resisting Distractions and Interruptions

The charge nurse describes hearing, but not responding to, an alarm that he believed to be noncritical. Although this could be described as “ignoring” the signal, from his perspective, checking a nonurgent alarm at that time would have interrupted his primary task of receiving an urgent report. Because of inherent (human) cognitive traits, nurses may delay response to unexpected events (eg, alarms) if it hampers work flow or interrupts tasks.27,56 Persons performing critical tasks (eg, sterile placement of a urinary catheter) or tasks with high entry demand (eg, tasks requiring full isolation precautions) are particularly prone to resisting or delaying response. Given the frequency of critical tasks, alarms, and alerts, nurses must resist abandoning tasks to accomplish safe, quality care and, in fact, they develop skills to interpret and decide on “appropriate” responses to alarms.27

Sound Discrimination and Alarms

The charge nurse heard an alarm, but he misattributed the source and did not accurately identify the location. Studies demonstrate that even experienced clinicians cannot recognize more than 50% of alarms in work settings.8,57,58 In addition, users expect devices to be intuitive60 and users’ perception of alarm urgency (ie, critical or noncritical sounding) directly influences response.8 Optimal acoustic (and visual) alarms ideally occur in a specific sequence or pattern that is readily heard and easy to interpret.55,61,62 Controversy remains
about the exact tone, frequency, and sequencing characteristics of a perfect alarm.\textsuperscript{9,61} Guidelines and standards for medical device alarm systems often offer conflicting direction and are not always evidence based.\textsuperscript{9,13,61} As a result, alarm signals do not consistently correlate with perceived criticality, and this lack of consistent correlation directly influences response.

**Alarm Management As a Skill Set**

Proactive alarm management is the best way to reduce alarm hazards, reduce excessive alarms, and prevent alarm fatigue.\textsuperscript{15} It is incorrect to view alarm management as a skill simply acquired implicitly through time and clinical experience.\textsuperscript{27} Analyses of alarm-related events often reveal that users do not understand the purpose of the system, did not have an optimal level of knowledge or training before use, or had not had clinical competence validated.\textsuperscript{12} In the clinical case, both of the nurses who cared for the patient (Pamela and Susan) had opportunities to manage the alarm settings and parameters proactively to reduce the frequency of clinically irrelevant alarms. The RCA also indicates that other, unit-level and facility-level factors contributed to the event, and the RCA team requests the unit and facility policies on alarm management.

The team reviews the policies, looking specifically at roles and responsibilities. A facility-level policy reads: “All staff are expected to respond immediately to all critical alarms.” Jackie, the nurse on the team, raises her eyebrows, “That’s just not practical. We’ve already determined that Matt didn’t know the alarm was critical, while Susan was busy changing a dressing and didn’t even hear it. And how can “all” of the nurses respond to “all” of the alarms all of the time? The team members agree the facility policy, as written, offers limited meaningful guidance for staff. They also review their unit policy, which states: “Telemetry monitoring technicians may not turn off or otherwise disable critical alarms without verifying with the patient’s assigned [nurse].” Several team members note that it was a nurse, not a technician, who changed the alarms, and that she did not disable the alarm, but “suspended” it. Others point out, however, that she was not the assigned nurse at that time. Jackie reports that her own orientation to the monitors was minimal, and most of her understanding of this particular system was acquired during day-to-day use.

### Roles and Responsibilities

Many elements of NPSG 06.01.01 are focused on establishing roles and responsibilities through policy and procedure, including who may make decisions about alarm parameters, who may change alarm settings, and who is responsible for responding to alarms and alerts.\textsuperscript{5} However, the mere presence of a policy does not translate into improved safety, as noted in the case study. Policy, procedure, and protocols may define responsibility without differentiating clearly between role, title, responsibility, and scope of clinical practice. Such tools may fail to address reasonably expected contingency scenarios (eg, a nurse watching the telemetry monitors). This failure can generate loopholes and inconsistencies in practices. In this case, the nurse watching the monitors is serving in a contingency role (monitor technician). Her decisions are based on clinical context and her clinical expertise; her actions are those of a nurse rather than a technician, and she may be unaware of the specific responsibilities or constraints on the telemetry technician. Based on unit policy, the nurse caring for the patient could reasonably assume that the monitoring technician (nurse or not) would not change alarm parameters. Alternatively, she may have adjusted her practice based on the fact that a nurse, especially one who had previously cared for the patient in question, was serving as the monitor technician.

In the clinical scenario, the facility level policy contains another flaw. Implementing policies that require “everyone” to respond to “all alarms” creates a sense of diffuse responsibility; when all nurses are expected to respond to all alarm signals, each individual may assume that someone else will attend to the alarm.\textsuperscript{12,64} Strong policies and procedures integrate alarm escalation plans, which delineate multiple levels of responsibility when there is no initial response, as well as time frames for notification.

### Clinical Alarm Safety: Implications for Nursing

Unit (and facility) level change is possible. Nurses have the opportunity to improve clinical alarm safety by (1) leading improvements in clinical alarm practice,
(2) contributing to the understanding and application of clinical alarm safety practice and evidence, (3) ensuring compliance with NPSG.06.01.01, (4) developing alarm response plans and resources, and (5) participating in retrospective and proactive analyses of alarm safety. Many resources for champions of clinical alarm safety are readily available on the Internet (Table 3), including published unit-level successes, such as those achieved

### Table 3 Clinical alarm safety resources

<table>
<thead>
<tr>
<th>Organization</th>
<th>Available resources and tools</th>
</tr>
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<tbody>
<tr>
<td><strong>American Association of Critical-Care Nurses (AACN)</strong>&lt;br&gt;AACN is an international specialty nursing organization representing more than 100,000 nurses who care for acutely and critically ill patients. The National Teaching Institute (NTI) is their annual meeting. <a href="http://www.aacn.org">www.aacn.org</a></td>
<td>NTI ActionPak: Strategies for Managing Alarm Fatigue Resources include webinars, predeveloped presentations, sample communication materials (e-mails, newsletters), access to published literature, journal club guides AENC practice alert for improving clinical alarm safety (2013)</td>
</tr>
<tr>
<td><strong>Association for the Advancement of Medical Instrumentation (AAMI)</strong>&lt;br&gt;AAMI is a not-for-profit organization of health care technology professionals focused on supporting development, management, and safe use of medical technology. <a href="http://www.aami.org">www.aami.org</a></td>
<td>Clinical alarms resources include an alarm parameter inventory, webinars, and unit-level experiences with improving clinical alarm management, published as part of the Safety Innovations series. Safety Innovations white papers include Cardiopulmonary Monitors and Clinically Significant Events in Critically Ill Children—Children’s National Medical Center Recommendations for Alarm Signal Standardization and More Innovation: the Christiana Care Health System Experience Using Data to Drive Alarm System Improvement Efforts, The Johns Hopkins Hospital Experience Plan, Do, Check, Act: Using Action Research to Manage Alarm Systems, Signals, and Responses, The Beth Israel Deaconess Medical Center</td>
</tr>
<tr>
<td><strong>Food and Drug Administration (FDA)</strong>&lt;br&gt;The FDA is the sole US agency regulating medical devices, in addition to pharmaceutical and food safety. <a href="http://www.fda.gov">www.fda.gov</a></td>
<td>FDA Patient Safety News (online videos) Searchable databases, including Manufacturer and User Facility Device Experience (MAUDE) device recalls and device-related alerts</td>
</tr>
<tr>
<td><strong>ECRI (formerly the Emergency Care Research Institute)</strong>&lt;br&gt;This independent non-profit organization has focused on alarm related events. ECRI remains an international leader in critical evaluation of medical technologies. <a href="http://www.ecri.org">www.ecri.org</a></td>
<td>Alarm Management Starter Kit and Alarm Safety Resource Site Resources include posters, guidance articles, risk assessments, tools, webinars, and sample communication documents Comprehensive, device-specific “guidance articles” and reviews Alarm Management Safety Reviews</td>
</tr>
<tr>
<td><strong>The Joint Commission (TJC)</strong>&lt;br&gt;The Joint Commission is an independent, nonprofit organization that accredits and certifies health care organizations worldwide. <a href="http://www.jointcommission.org">www.jointcommission.org</a></td>
<td>Sentinel Event Alerts Sentinel Event Alert 50 (2013): Medical Device Alarm Safety in Hospitals Sentinel Event Alert 25 (2002): Preventing Ventilator-Related Deaths Sentinel event data analyses from voluntarily reported events National Patient Safety Goal 06.01.01: Improving Alarm Management Educational tools, including an alarm safety webinar</td>
</tr>
</tbody>
</table>
at Johns Hopkins Hospital. These resources offer real life examples of the commitment and interdisciplinary perseverance required to make sustainable changes in clinical alarm safety. Table 4 summarizes specific unit-level interventions used at some of these organizations.32,38,65-68

Summary

Clinical alarm systems in acute and critical care health care settings "challenge human limits for recognition and actions."13 Understanding alarm-related terminology and the scope of contributing factors (including, but not limited to, alarm fatigue) will equip nurses to devise and implement appropriate strategies for alarm management at the individual practice level and beyond. CCN

Table 4 Unit-level clinical alarm safety interventions

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Unit-level interventions</th>
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<tbody>
<tr>
<td>Ongoing</td>
<td>Document and analyze baseline unit alarm conditions</td>
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<tr>
<td></td>
<td>Use a quality improvement/process improvement framework and small tests of change</td>
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<tr>
<td></td>
<td>Prepare for a long-term commitment of months to years</td>
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<td></td>
<td>Provide orientation to devices for all new staff</td>
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<tr>
<td></td>
<td>Create quick-reference “at a glance” material for each monitor</td>
</tr>
<tr>
<td></td>
<td>Establish interval (eg, annual) clinical alarm management refresher training and/or competency assessment</td>
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<tr>
<td></td>
<td>Collaborate with health technology experts, including vendors</td>
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<td></td>
<td>Promote “context awareness” (eg, silencing of alarms before routine clinical care)</td>
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<tr>
<td>Every shift</td>
<td>Conduct multidisciplinary assessment of necessity of monitoring individual patients, asking questions such as:</td>
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<tr>
<td></td>
<td>Is there a clinical index for physiological monitoring?</td>
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<tr>
<td></td>
<td>Are the physiological parameters being monitored the optimal choice for the clinical indication?</td>
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<tr>
<td></td>
<td>Would intermittent monitoring be adequate instead of continuous monitoring?</td>
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<tr>
<td></td>
<td>What are the criteria/goals for discontinuing or reducing monitoring?</td>
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<tr>
<td></td>
<td>Clearly define roles and responsibilities for monitoring, communicating, and responding to alarms</td>
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<tr>
<td></td>
<td>Check individual alarm signals for appropriate parameters for the clinical context, settings, audibility, etc</td>
</tr>
<tr>
<td></td>
<td>Evaluate appropriateness of staffing and monitoring</td>
</tr>
<tr>
<td></td>
<td>Is a different (higher or lower) level of care more appropriate for the clinical situation?</td>
</tr>
<tr>
<td>Daily</td>
<td>Eliminate redundancies in the monitoring systems causing excessive alarms</td>
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<tr>
<td></td>
<td>Schedule proactive assessment and changing of electrodes, sensors, leads, and remote telemetry monitor batteries</td>
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<tr>
<td></td>
<td>Use evidence-based skin preparation when applying sensors and electrodes</td>
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<tr>
<td></td>
<td>Have enough equipment and supplies (eg, batteries, leads)</td>
</tr>
<tr>
<td>Quarterly</td>
<td>Review clinical alarm and monitoring policies and protocols, including those related to patient handovers and transport</td>
</tr>
<tr>
<td></td>
<td>Verify that roles and responsibilities are clearly defined in policy and protocol, and align with current unit practice and staffing strategies</td>
</tr>
<tr>
<td></td>
<td>Complete an inventory to identify any new equipment or retired equipment update procedures as needed</td>
</tr>
<tr>
<td></td>
<td>Identify priority alarms on unit</td>
</tr>
<tr>
<td></td>
<td>Establish algorithm to indicate which are the most important signals to manage</td>
</tr>
</tbody>
</table>

* Multiple high-acuity units have improved clinical alarm safety and published their experiences in peer-reviewed journals and through the Association for Advancement of Medical Instrumentation (AAMI) Safety Innovation series.33,34-69 The AAMI white papers in particular are exceptional resources for units embarking on local improvement activities. These experiences provide valuable information for others seeking to undertake similar projects.

Financial Disclosures
None reported.

References
1. Association for the Advancement of Medical Instrumentation. Experts see marked improvement in alarms management awareness. AAMI News. 2013;89(2).


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Worldwide, about 15 million infants are born prematurely each year. Technological advances, including invasive mechanical ventilation, play a major role in the survival of extremely preterm babies. Those who survive may have prolonged morbid conditions that result in long-term sequelae. Nurses face several challenges during the hospitalization of these infants. Vigilant care, monitoring, and careful handling of the infants can prevent infections and long-term complications. Newer, less invasive technologies are promising for improved outcomes in extremely preterm infants. (Critical Care Nurse. 2015;35[4]:58-66)

According to estimates, worldwide 15 million infants are born preterm every year.¹³ Among these preterm infants, approximately 10% are born at 28 to less than 32 weeks’ gestation, and 5% are born at less than 28 weeks’ gestation.¹² Prematurity is the leading cause of death in the neonatal period and the second leading cause of death in children less than 5 years old.¹ Annually, 1.1 million infants die of direct complications of preterm birth.¹ The incidence, morbidity, and mortality of preterm infants continue to challenge health care providers even though the emergence of neonatal intensive care units (NICUs) and advanced technology has improved the infants’ survival.³

Most preterm infants require minimal respiratory support in the delivery suite; however, some may need invasive mechanical ventilation to initiate and sustain breathing.⁴ A few infants may require mechanical ventilation for a prolonged period. Prolonged ventilation is a concept that lacks consistency in definition: the duration considered prolonged can vary from more than 2 hours⁵ to more than 21 days.⁶ NICU nurses are in a pivotal position to influence the outcome of extremely preterm infants. In this article, I focus on preterm infants who require mechanical ventilation for a prolonged period and on nurses’ role in management so that potential complications can be avoided.

Mechanical Ventilation in Preterm Infants

The World Health Organization¹ categorizes infants born alive before 37 completed weeks of gestation into 3 categories: late and moderate preterm, which is 32 to less than 37 weeks (83% of all preterm births); very preterm, which is 28 to less than 32 weeks (10% of all preterm births); and extremely
Prematurity is the leading cause of death in neonates and the second leading cause of death in children less than 5 years old.

About 90% of extremely preterm infants born in high-income countries with access to full intensive care survive, whereas only 10% born in low-income settings with limited physical and human resources survive. The high survival rate in preterm infants can be attributed to the emergence of NICUs with sophisticated technology and excellent nursing care. About 10% of all infants born in the United States need some assistance in the delivery suite. Of these, 1% may need extensive resuscitation that includes intubation and mechanical ventilation. Around 50% of preterm infants with a gestational age of 24 to 28 weeks may require intubation and mechanical ventilation to maintain extrauterine life. Administration of surfactant, a natural lipoprotein, into the alveoli may relieve an infant’s respiratory distress. Although this treatment improves pulmonary function, a lack of alveolar growth reduces the surface area for gas exchange. The goals of mechanical ventilation include preventing atelectasis, maintaining adequate pulmonary gas exchange, reducing the work of breathing, and minimizing ventilator-induced lung injury.

Approaches to mechanical ventilation are highly variable and may be determined by the severity of an infant’s condition, available resources, and the experience of the care team. In addition, no standardized terminology for various modes of ventilation exists. Synchronized, patient-triggered, pressure-limited and volume-targeted, and high-frequency ventilation are the usual broad categories. Nitric oxide may be used to enhance vasodilatation and lung perfusion. Regardless of the type of ventilation used, the approach for each infant is individualized. When conventional mechanical ventilation is insufficient to maintain optimum gas exchanges, high-frequency ventilation with low-compliance tubing and connectors (jet ventilation or oscillatory ventilation) may be the treatment of choice. In these modes of mechanical ventilation, the fraction of inspired oxygen must be carefully adjusted to ensure optimum oxygen saturation.

Hypoxemia is usually due to ventilation-perfusion mismatch or to left-to-right shunting, and the underlying physiological condition may determine the mode and settings of ventilation. Each mode of mechanical ventilation and the individual settings have specific advantages and disadvantages (Table 1).

Most NICUs have specific protocols and algorithms that provide guidelines for beginning or changing the ventilator settings. The decision on how to alter the settings is influenced by a constant interplay of factors, such as the infant’s hemodynamic status, progression and regression of the infant’s condition, lung pathological conditions, response to ventilator changes, and results of blood gas analysis. Despite efforts to wean an infant from mechanical ventilation, some infants require prolonged ventilation to allow the lungs to heal.

Ongoing observation and monitoring help in achieving well-timed extubation and in preventing complications. Reliance on proper criteria for extubation, such as the spontaneous breathing test, in addition to clinical judgment, may obviate reintubation. Vigilant observation, continuous monitoring, and regular clinical assessments are essential to recognize early warning signs of complications of mechanical ventilation, including ventilator-associated pneumonia, lung injury, chronic lung disease, infections, air leak syndrome, retinopathy of prematurity, malformations of the nasal and oral cavities, and skin complications. Appropriate synergy between the infant’s effort to breathe and the technology used can minimize volutrauma (volume-induced trauma to the lung) and barotrauma (pressure-induced trauma to the lung).

Challenges for Nurses

Nurses caring for an infant receiving mechanical ventilation face many challenges. Expertise and extreme care are important aspects in providing safe and effective care. Cardinal aspects of care include thermoregulation, optimal positioning, airway clearance, stable hemodynamic status, and adequate nutrition for maintenance of growth and development. In addition, prolonged mechanical ventilation is associated with acute
complications such as infection and accidental extubations and long-term complications such as chronic lung disease, subglottic stenosis, and neurodevelopmental problems. A summary of these challenges and possible courses of action are given in Table 2.

Thermoregulation
Thermoregulation is a vital determinant of morbidity, mortality, and optimum health outcome in infants, particularly premature infants. Invasive procedures requiring prolonged access to an infant, such as umbilical
catheterization, intravenous access, and radiographic procedures, may jeopardize thermal stability. The risk for heat loss and resulting hypothermia is more profound in preterm infants than in term infants because of the preterm infants’ limited brown fat and immature heat-preserving mechanisms. Hypothermia has been
independently associated with increased energy consumption, neonatal cold injury (as evidenced by lethargy and oliguria), poor weight gain, and susceptibility to infection that may jeopardize the condition of a neonate. Therefore, routine neonatal critical care includes measures to reduce heat loss by evaporation, conduction, convection, and radiation and use of methods to maintain normothermia. Judicious limited access into the incubators by care providers or infants’ family members may help prevent heat loss. Use of humidity, plastic wraps, and other accessory heating or warming equipment such as water-circulating heating pads help with transfer of heat. Positioning devices such as “snugglies” (devices with a cloth boundary for infants to brace their feet and straps to contain their arms) help conserve heat and can influence thermoregulation. Some challenges to neonatal thermoregulation are the infant’s size and gestational age and the care team’s need for access during procedures and assessments. The temperature of the humidifier in the ventilator circuit and buildup of condensation in the tubing also must be monitored to ensure the temperature of the inspired gases, which in turn affects thermoregulation.

Positioning and Maintaining a Patent Airway

Positioning an infant who is receiving mechanical ventilation can be a challenging task. Although a comfortable position is essential for rest, an infant’s position can affect chest expansion, patency of the endotracheal tube, and circulation. Benign routine care activities have been linked to changes in cerebral blood flow patterns, possibly contributing to intraventricular hemorrhages. Positioning devices and adequate boundaries help provide a stable position for an intubated infant. After reviewing literature and consulting experts in neurophysiology, Malusky and Donze recommended midline head positioning for preterm infants to prevent intraventricular hemorrhage but did not reach any conclusion about the duration of midline positioning. Maintaining an infant in the midline position while keeping the endotracheal tube secure in an optimum position in the short, narrow trachea is critical to ensure a stable hemodynamic status. Nurses prefer to position infants prone, because this position is better than the supine position for good oxygenation in preterm infants receiving mechanical ventilation. Compared with the supine position, skin-to-skin (kangaroo) care and the prone position were not factors for any variability in hemodynamic status in preterm infants.

Endotracheal suctioning is needed to maintain airway patency. The pressure, depth, and duration of suctioning are factors that can affect ventilation and oxygenation. Suctioning or position changes must be performed with extreme care because these procedures may increase cerebral perfusion and intracranial pressure. Such changes in perfusion and pressure can increase the risk for intraventricular hemorrhage and long-term sequelae such as cerebral palsy in extremely preterm infants. Head sonography is routinely performed on days 4 and 30 of life for extremely preterm infants for early detection of any intraventricular hemorrhage. Sonography sometimes requires that infants be repositioned, a situation that may cause stress, leading to bradycardia and desaturations. Warming up the gel used for the procedure may prevent cold stress in infants undergoing head sonography.

Maintaining a Stable Hemodynamic Status

Continuous cardiorespiratory and oxygen saturation monitoring is the standard of care in every NICU. In addition, infants receiving mechanical ventilation may have continuous arterial pressure monitoring and preductal and postductal pulse oximetry. The vital signs can change rapidly. A slight movement of the head may dislocate the endotracheal tube, triggering a vagal reflex and resulting in bradycardia, desaturations, or other inadvertent hemodynamic changes. An abrupt movement of the head may kink the endotracheal tube and generate the same effect. Highly sensitive equipment is helpful for monitoring. Alarm limits (upper and lower) for heart rate, respiration, blood pressure, and oxygen saturation are set on the basis of current evidence and the NICU’s specific standard of care. The American Academy of Pediatrics recommends that oxygen saturation measured by pulse oximetry be maintained at 90% to 95% for low-birth-weight and preterm infants and at 95% or higher for term infants. Although vigilant monitoring is essential for making changes in treatment, interventions, and validation of clinical progress, some infants become dependent on the mechanical ventilator for several weeks or months. As an
Infant matures and becomes more active, maintaining the endotracheal tube in place can be difficult.

**Nutrition and Feeding**

A preterm baby may have abnormalities in fluid and electrolyte imbalance because of inadequate intake, frequent collections of blood specimens for laboratory tests, and evaporative losses. Feeding intolerance is a common complication of preterm birth. Enteral feeding is ideal for optimum growth and development and prevention of infection in a preterm infant. Practitioners vary in their process of initiating and advancing the feedings in preterm infants. Early initiation of trophic feeding is beneficial to all infants, particularly extremely preterm infants. The volume of feeding may be advanced carefully and as tolerated on the basis of institution-specific protocols. Stable hemodynamic status and existing pathological changes and anomalies may determine the process used. Nonetheless, Eicher et al. reported that hypoxemia and poor mesenteric perfusion leading to necrotizing enterocolitis can be primarily related to prematurity. Necrotizing enterocolitis may delay feeding attempts and necessitate surgical intervention, including bowel resection, ileostomy or colostomy, leading to prolonged hospitalizations. Therefore, total parental nutrition is routinely used for these infants regardless of gestational age to meet nutritional needs until the infants can tolerate full-volume feedings. Practitioners must adjust the micronutrients daily; prolonged use of total parental nutrition can lead to complications such as cholestasis, infections, and longer hospitalizations. Intravenous access adds to the risk for infection in extremely premature infants. Prolonged intubation necessitates tube feedings for extended periods. This duration of tube feeding in addition to lack of oral motor stimulation can result in nipple aversion. Nipple aversion can result in slow progress in oral feeding, thereby delaying discharge to home.

**Complications**

**Prevention of Infection**

Extremely preterm infants are highly vulnerable to infection. Intrauterine infection can be a cause of premature birth. Risk for infection is higher in extremely preterm infants because artificial airways bypass the normal filtering of inspired air, thereby fostering microbial growth. The infants are also at risk for necrotizing enterocolitis, sepsis, respiratory infection, and fungal infections. Infants with sepsis can become critically ill, and a higher rate of cerebral palsy has been reported in infants with sepsis. In addition, surgeries such as ligation of a patent ductus arteriosus may increase the risk for infection.

All personnel in the NICU must adhere to the infection control policies to provide a safe environment for the infants in the unit. Hand washing, isolation, surveillance, seasonal screening of visitors for potential infection, and validating the immunization status of the sibling visitors may be challenging. Nurses must advocate for premature infants to ensure patient safety and prevent infection that can lead to long-term sequelae.

**Prevention of Unplanned Extubation**

Maintaining an artificial airway for a prolonged duration is essential. Sudden and unexpected movement of an infant’s head can dislodge the endotracheal tube from the trachea. Unplanned extubation can also happen during routine care or transfer of infants to parents for skin-to-skin care. Nurses may encounter challenges such as short tracheas, which can lead to quick extubation, and small endotracheal tubes (internal diameter 2 mm) that are easily blocked. In addition, nonadherence of the securing device (to secure the endotracheal tube) to the skin because of secretions, poor skin integrity, and a small
face on which to place the securing device pose additional challenges. Smaller airways make reintubation difficult. Vigilance by nurses is absolutely essential to maintain a patent airway and prevent inadvertent extubation.

**Chronic Lung Disease, Subglottic Stenosis, Retinopathy of Prematurity**

The potential long-term effects of mechanical ventilation and oxygen administration include volutrauma, baro-trauma, and retinopathy of prematurity. Preterm infants with prolonged duration of mechanical ventilation may become dependent on the ventilator. In addition, prolonged mechanical ventilation increases the risk for chronic lung disease. Steroids may be used to reduce the inflammation in chronic lung disease, although the role of these drugs has not been fully established. Infants at increased risk for airway edema and obstruction may benefit from steroids, thereby avoiding reintubation after a planned extubation. Infants intubated for prolonged periods are also at risk for subglottic stenosis, which can result in airway obstruction and may require laryngotraheal reconstructive surgery or a tracheostomy for maintaining an open airway. Infants who require such surgery may require careful coordination of care, including training of parents in tracheostomy care and subsequent home care. This need for training is an additional challenge to NICU nurses. The nurses must ensure that parents are competent in tracheostomy care before an infant with a tracheostomy is discharged home.

**Poor Neurodevelopmental Outcome**

The results of studies on neurodevelopmental outcome and rate of disability in preterm infants are conflicting. Neurodevelopmental disabilities in preterm infants may include cerebral palsy, mental retardation, and visual and hearing impairments. In a study of 50 extremely premature infants, Serenius et al found severe mental developmental delay (78%), severe cerebral palsy (12%), and blindness (8.2%). The proportion of moderate or severe disabilities increased with the decrease in gestational age; 60% at 22 weeks to 17% at 26 weeks (P < .001 for trend). Boys (31%) were more prone to disability than were girls (23%). In other studies, family-centered and developmental care and sociodemographic factors were associated with better neurodevelopmental outcomes. Neurodevelopmental outcomes did not vary with a higher level of NICU care. Extremely premature infants may experience other disorders of central nervous system functions, including language disorders, learning disabilities, attention deficit hyperactivity disorder, neuromotor dysfunction, and behavioral and social-emotional difficulties. These infants may experience more difficulties at school, resulting in poor academic achievement later in life. Low levels of education among parents and social disadvantages are also associated with neurodevelopmental outcome in preterm infants.

**Economic and Financial Impact of Prolonged Mechanical Ventilation on Infants’ Families and Community**

The long-term effect of prematurity requiring prolonged mechanical ventilation may include poor quality of life of the child and the child’s family members, poor neurodevelopmental outcome, and extended use of technological support for life sustenance, effects that can economically deplete a society. This economic need can become a societal, legal, and organizational challenge. The cost associated with preterm birth in the United States was $26.2 billion in 2005. In addition, the cost of community resources during birth, hospitalization, and continued support services through school years and beyond are substantial. Out-of-pocket expenses can destabilize a family’s finances as well. The cost of care of a premature infant increases as the gestational age decreases.

**Ethical Issues**

Several medically fragile infants who have survived with severe sequelae have generated much debate.
about the ethics of aggressive care. When treatment is offered to infants with a very low level of predictable survival, the decision making becomes hard on parents and health care providers. The Institute of Medicine reported that in instances in which health care providers recommended withholding treatment but parents refused to allow the withholding, the number of days an infant survived increased but the overall outcome was not affected. NICU nurses can feel dispirited when their efforts become futile and death happens after they have spent busy, emotionally charged hours caring for an infant. When such a scenario occurs often, caregivers can experience emotional exhaustion.

Newer Perspectives and Future Methods of Mechanical Ventilation

Invasive mechanical ventilation is the common method of establishing and maintaining ventilation in infants who are born extremely premature. However, the complications of mechanical ventilation can result in major and irreversible damage to the health and well-being of the child and the child’s caregivers. Older methods such as bubble continuous positive airway pressure, nasal continuous positive airway pressure, and nasal intermittent noninvasive positive pressure ventilation are increasingly being used now in NICUs globally. The optimal method that can lead to better outcomes is a matter of debate. For example, the outcome report from New York Presbyterian Hospital indicated that these noninvasive methods of ventilation produced significantly better results in preterm infants than did other methods. Laryngeal mask ventilation is also used by some practitioners for short-term mechanical ventilation or transport purposes. Newer methods of ventilation such as the neurally adjusted ventilator assist method, which can be used invasively or noninvasively, in which the ventilation is controlled by diaphragmatic electrical activity, may gain popularity in NICUs.

Practices such as use of a minimally invasive approach in the delivery suite and early administration of surfactant may help reduce the number of infants who undergo prolonged mechanical ventilation and its long-term complications. However, having staff who are sufficiently trained in the use of any mode of mechanical ventilation is essential for successful implementation and optimal outcomes.

Conclusion

Initiation of resuscitation may enhance the survival of preterm infants, and some of these infants may need prolonged mechanical ventilation. Nevertheless, attempts to reduce morbidity and long-term sequelae of prematurity have been unsuccessful. Prolonged mechanical ventilation in preterm infants presents many challenges. Providing quality care requires up-to-date evidence-based knowledge, emerging noninvasive technology, and competent staff. Evaluating and continuously improving the care processes, monitoring the quality indicators for progressive positive trends, and ongoing supervision of care may reduce morbidity and long-term sequelae. Early use of continuous positive airway pressure, early extubation, selective intubation, and use of spontaneous breathing tests for timely extubation may improve outcome in infants who are born prematurely. Research on the methods of mechanical ventilation, the outcome in infants, and the economic impact may change trends in caring for preterm infants.

Acknowledgments

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Financial Disclosures

None reported.

References


Change Is the Only Constant in Critical Care

In order for certification examinations to accurately reflect current clinical practice, the content outline (blueprint) and test questions must change with practice changes. Since its introduction in 1976, the CCRN blueprint has gone through many revisions and updates. In the summer of 2015, the New Blueprint was introduced, and the test will begin reflecting these changes in October 2015. Examination candidates are encouraged to review all of the certification handbook, along with the resource and support materials, available under the certification tab at www.aacn.org when preparing for any of the acute or critical care certification examinations.

Adult CCRN Practice Questions

1. When providing culturally sensitive care, nurses should understand that
   A. All members of a specific culture hold the same beliefs
   B. It is important to place every patient on the same standards of care
   C. Best practices take precedence over individuals’ expressed needs
   D. It is essential that the patient’s goals are an important part of care planning

Test plan topic: Caring and Professional Practice, 20% of the CCRN questions

2. A 3-day postoperative thoracotomy patient has a heart rate (HR) of 125/min, respiratory rate (RR) of 36/min, blood pressure (BP) of 164/84 mm Hg, is diaphoretic, has dilated pupils, is agitated, denies pain, and appears to be having tactile hallucinations, which he describes as “bugs crawling” on him. Despite frequent reorientation from the nurse, the patient continues to try to climb out of bed. The best strategy to minimize systems would be?
   A. Administer lorazepam (Ativan)
   B. Place soft restraints on the patient
   C. Administer methadone
   D. Ask a family member to remain with the patient

Test plan topic: Behavioral, 4% of the CCRN questions; Behavioral, Psychosocial, Neurological, and Musculoskeletal combined are 13% of the 2015 CCRN questions

3. The nurse reports in multidisciplinary rounds that a patient receiving gastric enteral feedings has had residual volumes of more than 200 mL several times in the past few days. The nurse should anticipate which of the following orders?
   A. Discontinue enteral and begin parenteral nutrition
   B. Withhold enteral feedings for 24 hours and recheck residual volumes

Contributors

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Cheryl Herrmann, RN, MS, APN, CCRN, CCNS-CS-CMC, cardiac clinical nurse specialist, UnityPoint Health Methodist, Peoria, Illinois, submitted PCCN questions 1 through 4.

Mychell Zepeda, RN, BSN, MSN, PCCN, clinical lead nurse and preceptor, UnityPoint Health Methodist, submitted PCCN question 5.
C. Start the patient on a prokinetic medication
D. Add protein powder to the enteral formula

Test plan topic: Gastrointestinal, 5% of the CCRN questions; Gastrointestinal, Hematology, Endocrine, Renal, and Integument combined are 19% of the 2015 CCRN questions

4. Which of the following assessment findings would be consistent with a serum potassium level of 7.2 mmol/L?
A. Muscle cramps, oliguria, short PR interval, bradycardia
B. Anxiety, hunger, tachycardia, long QT measurement
C. Confusion, thirst, long PR interval, numb fingers
D. Anorexia, fatigue, wide QRS complex, tall T wave

Test plan topic: Renal, 6% of the CCRN questions; Gastrointestinal, Hematology, Endocrine, Renal, and Integument combined are 19% of the 2015 CCRN questions

5. The rationale for considering a heparin infusion in the management of disseminated intravascular coagulation (DIC) is to
A. Dissolve the clots that have developed
B. Decrease the formation of new clots
C. Disrupt platelet aggregation
D. Block the formation of fibrin

Test plan topic: Hematology, 2% of the CCRN questions; Gastrointestinal, Hematology, Endocrine, Renal, and Integument combined are 19% of the 2015 CCRN questions

Correct Answers and Rationales for Adult CCRN Practice Questions

1. Correct Answer: D
Rationale
All patients should be treated as individuals first. Members of the same religious, social, or ethnic group may hold some common beliefs (A) within every culture, but individual differences and personal preferences may also affect needs for care. Standards of care (B) are developed with best practices (C) in mind and evidence-based guidelines to support their implementation, but again the patient’s wishes and goals should be an important driving force in care planning.

Source

2. Correct Answer: A
Rationale
These assessment findings are common in alcohol withdrawal or delirium tremors. The sympathetic stimulation, tactile hallucinations, and the fact that the symptoms are occurring 72 hours after admission are contributing data points. More assessments would be done before lorazepam would be given, but among the options to choose from, it is the most appropriate choice. Restraining (B) the patient is not appropriate at this point. Ensuring the patient’s safety while investigating and treating the primary cause of the behavior would come before restraints would be applied. The assessment data do not demonstrate opiate withdrawal, so methadone (C) is not indicated. Although a family member (D) might be able to assist with calming and reorienting the patient, family members are not responsible for the patient’s safety.

Source

3. Correct Answer: C
Rationale
Consistently high gastric residual volumes could contribute to an increased risk of aspiration. Evidence-based practice recommendations suggest adding a prokinetic medication to enhance gastric motility to help decrease residual volumes. Enteral nutrition is the first choice (A) for feeding, so everything that can be done for successful enteral feeding should be done before parenteral feeding is considered. Withholding the feeding (B) should not be done until everything to promote enteral feedings has been attempted. In this case, if the prokinetic medication does not help, the feeding site might be changed from the stomach to the small bowel. Protein powder (D) is often used with enteral feedings but will not directly help decrease the gastric residual volumes.

Sources
4. Correct Answer: D  
Rationale  
An elevated serum potassium (> 5.5 mmol/L) could be caused by too much intake (administration), inability to excrete (renal dysfunction), acidosis (diabetic ketoacidosis [DKA]), or tissue damage (crush injuries). High extracellular level of potassium affects the Na/K-ATPase pump, with the most immediate issues relating to ventricular rate and conduction.

Source  

5. Correct Answer: B  
Rationale  
DIC is a secondary disorder in which clotting has led to a bleeding state. The combination of tissue, platelet, and endothelial damage initiates intravascular clotting and fibrinolytic mediator release. The rationale for giving heparin is that if the clotting is stopped, the production of fibrinolytic mediators will then cease, not to break up the clots that have developed (A). Heparin is an anticoagulant, not an antiplatelet (C). Heparin blocks the formation of thrombin, not fibrin (D).

Source  

PCCN Practice Questions

1. Following placement of a dialysis catheter into the left subclavian vein (LSCV), a patient becomes abruptly dyspneic and complains of sharp pain in the upper left part of the chest. The assessment reveals labored breathing with a respiratory rate of 30/min, oxygen saturation by pulse oximetry (SpO₂) 89%, and absent lung sounds on the left side. The nurse should suspect  
A. Pulmonary embolus and prepare a heparin infusion  
B. Pneumothorax and prepare for emergency chest tube insertion  
C. Liver laceration and prepare the patient for the operating room  
D. Subclavian vein perforation and prepare for emergency thoracentesis

Pulmonary, 14% of the PCCN test questions

2. A patient with a history of heart failure who was admitted for syncope has a blood pressure of 85/50 mm Hg and is becoming less responsive. Analysis of the electrocardiography (ECG) strip reveals P waves at a rate of 75/min and a QRS rate of 30/min with intervals of 140 msec; there is no correlation between the P waves and the QRS complexes. A priority intervention by the nurse would be to  
A. Prepare for cardioversion  
B. Prepare for defibrillation  
C. Prepare for atropine administration  
D. Prepare for transcutaneous pacing

Cardiovascular, 33% of the PCCN test questions

3. Two days after a thoracotomy, a patient complains of chest pain. A 12-lead electrocardiogram reveals ST-segment elevation in leads II, III, and AVF and ST-segment depression in leads I and AVL. In addition to preparing the patient for cardiac catheterization, the nurse should recognize the patient is at risk for  
A. Third-degree heart block with ventricular escape rhythm  
B. Ventricular tachycardia with a pulse  
C. Sinus rhythm with premature ventricular complexes  
D. Atrial fibrillation with rapid ventricular response

Cardiac, 33% of the PCCN test questions

4. A 75-year-old patient admitted with urosepsis becomes hypotensive and short of breath. The patient’s family attempts to block transferring the patient to the intensive care unit (ICU). They feel it is unnecessary for a urinary tract infection and state, “You are just trying to increase the hospital bill!” The most appropriate response by the progressive care nurse would be  
A. “Your mother is very sick, please let me do my job.”  
B. “I need you to leave. Please go to the waiting room. I will call someone to meet you there and explain what is going on.”  
C. “Your mother may need treatments we cannot provide on this unit, her infection appears to be getting worse.”

Pulmonary, 14% of the PCCN test questions
D. “The ICU physician will explain everything to you after the transfer.”

Behavioral, Neurological, and Multisystem together are 15% of the PCCN test questions

5. A 21-year-old patient with a known history of an eating disorder and long-term use of suppositories with diarrhea is admitted from the emergency department with nausea and diarrhea for 1 week. Which acid-base imbalance would be consistent with this presentation?

A. pH 7.29, PaCO₂ 47 mm Hg, HCO₃⁻ 22 mm Hg, HR 55/min, RR 30/min
B. pH 7.43, PaCO₂ 37 mm Hg, HCO₃⁻ 25 mm Hg, HR 74/min, RR 20/min
C. pH 7.25, PaCO₂ 40 mm Hg, HCO₃⁻ 15 mm Hg, HR 50/min, RR 23/min
D. pH 7.50, PaCO₂ 33 mm Hg, HCO₃⁻ 20 mm Hg, HR 115/min, RR 30/min

Pulmonary, 14% of the PCCN test questions

Correct Answers and Rationales for PCCN Practice Questions

1. Correct Answer: B

Rationale
The absent lung sounds on the left side and recent procedure (puncture of the subclavian vein) makes pneumothorax a high probability. Pulmonary embolus (A) is often manifested by acute respiratory distress and chest pain but typically occurs with ambulation and not after insertion of a central catheter. A liver laceration (C) would not affect lung sounds. A subclavian vein perforation (D) could cause a hemothorax.

Source

2. Correct Answer: D

Rationale
The rhythm described is third-degree heart block. The atrial rate (P waves) and ventricular rate (QRS) will be different. The hypotension and decreasing level of consciousness identify the problem as symptomatic third-degree heart block, which requires pacing. Emergent cardioversion (A) or defibrillation (B) is indicated for supraventricular tachycardia, ventricular tachycardia, or ventricular fibrillation. Atropine (C) is a drug that might be used for bradycardic rhythms or when transcutaneous pacing is not available or not working.

Source

3. Correct Answer: A

Rationale
The leads indicative of an inferior ST-elevation myocardial infarction (STEMI) are II, III, and AVF. The ST-segment depressions are reciprocal changes noted in the lateral leads (I and AVL) that are opposite the inferior leads. The right coronary artery (RCA) supplies oxygen to the sinoatrial (SA) and atrioventricular (AV) nodes and the inferior portion of the left ventricle in most people. Blockage of the RCA may cause bradycardia and heart blocks. Options B and C are rhythms that are associated with blockage of the left anterior descending artery (LAD) and therefore typically cause ventricular ectopy. The LAD supplies the anterior ventricle and correlates with leads V₃ and V₄. New-onset atrial fibrillation (D) is associated with valvular or atrial electrical problems, not typically with decreased coronary perfusion and acute coronary syndrome (ACS).

Source

4. Correct Answer: C

Rationale
Hospitalization is a stressful event for both patients and their families. Clear, honest, and consistent communication from the health care team is essential. Not answering their question (A) might frustrate the family more. Asking them to leave (B) also is a nonresponse to their statement/accusation. Delaying explaining (D) might increase their distrust and fear.

Source

5. Correct Answer: C

Rationale
Metabolic acidosis is caused by either a loss in base or an increase in acid in the body. A loss of bicarbonate...
(base) occurs with diarrhea. Patients with eating disorders may also have compromised renal function, which could affect the kidney’s ability to excrete hydrogen ions and thus contribute to metabolic acidosis. Respiratory acidosis (A) is most commonly seen with hypoventilation states and (D) with hyperventilation. Option B is a normal acid-base balance.

**Source**

AACN Certcorp publishes a study bibliography that identifies the sources from which items are validated. The document may be found in the AACN Certification exam handbook. The contributor of each question written for this column has listed the source used in developing each item. CCN
Ask the Experts

Prone Position for Acute Respiratory Distress Syndrome

Q

What is the current science on prone positioning and what are the nursing implications?

A

Pol-Andre Senecal, MSN, NP, CNS, ACNP, CCNS, replies:

This is a very timely question as recent changes in the evidence supporting prone therapy have the potential to radically change the approach to patients with severe acute respiratory distress syndrome (ARDS). Positioning patients face-down in a prone position was first studied as a method to improve oxygenation in patients with acute respiratory failure in the mid-1970s.1,2 Subsequent studies of prone positioning continued to demonstrate improved oxygenation in patients, but the impact on survival remained disappointing3,4 and the intervention remained a rescue therapy to be used only when more conventional approaches failed and the patient’s condition was deteriorating.5

The wisdom on prone therapy changed in 2013 when a team of researchers in Europe published the landmark PROSEVA, multicenter, prospective, randomized, controlled trial in the New England Journal of Medicine.6 The researchers randomized 466 patients with severe ARDS (in 27 hospitals in France and Spain) to either a control group or an experimental group. Patients in the experimental group were positioned face-down within 12 to 24 hours of diagnosis, and remained in that position for a target time of 16 hours. After 16 hours, prone patients were returned to the supine position for 4 hours and then reassessed. If the ratio of PaO₂ to fraction of inspired oxygen (P/F) remained less than 150 mm Hg, the patient was returned to the prone position. Patients in the experimental group had a 51% mortality reduction compared with patients in the control group.

A subsequent meta-analysis7 that included the PROSEVA study indicated that prone therapy in addition to standard therapy reduced mortality by 26%. The benefit was seen in patients who were prone for at least 16 hours and who experienced severe hypoxemia (P/F <100 mm Hg) but not mild (P/F 200-300 mm Hg) or moderate (P/F 100-200 mm Hg) hypoxemia.8 Early initiation of prone therapy appears to be an important factor for success.

The mortality benefit of prone therapy appears to be related to improved oxygenation and a reduction in the injurious nature of mechanical ventilation in ARDS, but how prone therapy achieves this remains incompletely understood. Theoretical science, studies in animal models, and limited studies in humans suggest that the prone position decreases the atelectatic effects of gravity and anatomy, improves ventilation perfusion matching, and allows more equal distribution of pressure, minimizing progressive lung injury.9-11
The results of the PROSEVA study and subsequent meta-analysis are likely to lead to increased use of prone therapy, for which there are a number of nursing considerations. Nurses should familiarize themselves with the current evidence supporting prone therapy, including the indications, contraindications, details of the procedure, complications of the therapy, and measures to prevent complications.

Prone therapy is appropriate for patients with early, severe ARDS marked by P/F ratios of 150 mm Hg or less on mechanical ventilation with an Fi\textsubscript{O\textsubscript{2}} of at least 0.6 and a positive end-expiratory pressure (PEEP) of at least 5 cm H\textsubscript{2}O. Contraindications to prone positioning of ARDS patients include (1) increased intracranial pressure or decreased cerebral perfusion, (2) immediate need for a surgical or interventional procedure, (3) recent thoracic surgery including tracheostomy and pacemaker placement, (4) hemodynamic instability, (5) recent facial trauma or surgery, (6) pregnancy or abdominal compartment syndrome, and (7) unstable fractures of the spine, pelvis, or femur. Nurses are in an excellent position to advocate for the intervention when indicated and when the procedure is within the capabilities of the facility and staff caring for the patient.

This last point is important because every study reviewed or cited herein makes note of the unique challenges of caring for prone patients, including unplanned displacement of support lines and tubes, unexpected hospital-acquired pressure ulcers, and delays in care when resuscitation efforts are called for. Routine care such as suctioning and oral care for the prevention of ventilator-associated events may also be challenging, although the data appear to suggest that prone positioning of patients does not increase the incidence of ventilator-associated pneumonia.\textsuperscript{12} Use of a 25° reverse Trendelenburg position may offer additional benefit and supports the safe administration of enteral nutrition.\textsuperscript{13}

Injuries of hospital staff turning patients to the prone position have also been reported, suggesting that adequate numbers of staff employing excellent body mechanics are essential.\textsuperscript{14}

The PROSEVA authors considered the use of a strict protocol for positioning patients prone and the extensive experience of the staff performing the procedure as likely contributors to the mortality benefit they observed. Centers considering adopting this practice are encouraged to adopt similar protocols for the provision of prone therapy and subsequent care of the patient to ensure optimal outcomes as well as patient and staff safety.

Prone therapy presents new challenges to the prevention of hospital-associated pressure ulcers, and data from the PROSEVA study suggest a higher incidence of pressure ulcers that are stage II or worse in prone patients. This increased incidence appears to be driven by ulcers on the face and anterior surfaces, anatomic zones not typically affected by pressure. Nurses caring for prone patients must consider the anterior anatomic structures susceptible to pressure-related injury when positioning patients. These include facial structures such as the temporal bones and the zygomatic processes, the head of the humeri, the clavicle, the manubrium, the anterior iliac spines, the patellae, and the dorsal surfaces of the feet.\textsuperscript{15}

Very limited data are available from the critical care setting to guide practice related to prevention of pressure ulcers in prone patients. The PROSEVA authors note that they turned patients’ heads every 2 hours, applied prophylactic colloid dressings to at-risk anatomy, and implemented standard prevention when possible, but that is the extent of their guidance. Routine use of prophylactic dressings, however, does not appear beneficial.\textsuperscript{16} What other data are available predate the PROSEVA study, suggesting the need for further study, but in the absence of a clear contraindication, it appears reasonable to reposition patients side-to-side at least every 2 hours to offload pressure.\textsuperscript{17,18}

In summary, prone therapy offers significant benefit to selected patients; however, evidence to guide the nursing care of these patients remains incomplete. Until further study is completed and in the absence of contraindications, it appears reasonable to provide the same standard of care afforded supine patients to prone patients. CCN

Financial Disclosures
None reported.
References


Cochrane Review Summary
A summary of findings from the Cochrane Library with implications for critical care nursing

Debridement for Surgical Wounds
Christine Moreno Smith, RN, MSN

Review Question
What method of debridement is the most effective in removing dead tissue from surgical wounds that have become infected?

Relevance to Critical Care Nursing
Debridement is the removal of nonviable tissue and foreign matter from a wound. It is a naturally occurring event in the wound repair process. During the inflammatory phase, neutrophils and macrophages digest and remove debris from the wound area. Most surgical wounds heal naturally without delay or complications. However, complications such as infection and wound dehiscence may occur, and this natural repair process could become overwhelmed and insufficient due to the buildup of infected, contaminated tissue, cell debris or dead, devitalized, fibrous material. This buildup of nonviable tissue then places a higher demand on the wound and may cause the wound to have delayed healing, thus requiring removal of this tissue. Several debridement methods can be used for removal of nonviable tissue from these wounds, including surgical, biosurgical (larval debridement), autolytic, mechanical, chemical, and enzymatic debridement.

Debridement is a critical component of topical therapy for necrotic wounds. Health care professionals are vital in wound assessment, deciding whether debridement is appropriate, which method to use, and whether a specialist referral is required. Close supervision of the patient and accurate wound assessments during the debridement phase are essential to ensure an outcome consistent with wound goals.

Study Description and Results
This Cochrane summary is based on a review\(^1\) of 5 randomized controlled trials (RCTs; n= 159) that compared treatments for infected surgical wounds and reported time required to achieve a clean wound bed. Patients of any age, in any care setting, with a surgical wound that required debridement were included. Studies were excluded if wounds were not caused by surgery (ie, trauma wounds, burns, abscesses, pressure ulcers, leg ulcers, diabetic foot ulcers, fungating tumors, and wounds caused by the removal of foreign bodies). Of the 5 RCTs included in this review, 4 compared the effectiveness of dextranomer beads or paste with other products (different comparator in each trial) to achieve complete debridement, and 1 study compared an enzymatic agent (streptokinase/streptodornase) with saline-soaked dressings.

Primary outcomes included
- Time to complete debridement
- The proportion of wounds completely debrided during the trial period
- The rate of reduction in wound size expressed in either absolute or relative terms

Author
Christine Moreno Smith is a clinical nurse educator at the Institute for Nursing Excellence, University of California San Francisco (UCSF) Medical Center and a certified Joanna Briggs Institute (JBI) Comprehensive Systematic Review trainer at the UCSF JBI Centre for Evidence-Based Patient and Family Care, San Francisco, California.

For questions related to this article, contact Christine Moreno Smith at chrissie.smith@ucsf.edu.

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• The proportion of wounds completely healed during the trial period
• Time to complete healing

Secondary outcomes of interest in the study were
• Patient satisfaction (eg, pain associated with treatment as recorded by using a recognized pain scale)
• Rate of infection
• Quality of life
• Length of hospital stay
• Cost-effectiveness (eg, as presented in a cost-effectiveness analysis, which may include nursing time, time taken to change dressing, number of dressing changes required, cost of dressing materials)
• Serious adverse events (life-threatening or those leading to hospitalization)
• Other adverse events (those leading to discontinuation of treatment)

Risk of bias was assessed by using the Cochrane Collaboration tool. All 5 RCTs were classified as unclear for the majority of the 4 key criteria for bias. Two of the 5 studies were found to have a low risk of randomization bias, and 2 studies had a low risk of allocation concealment. Only 1 study reported that the outcome assessor was blinded to the intervention, and none of the included studies reported blinding of participants or personnel involved in the care of the participants. RevMan5 was used to calculate the overall effect size with 95% confidence interval. Time to wound healing and time to return to work were analyzed as survival (time to event) data by using the appropriate analytical method (as per the Cochrane Handbook for Systematic Review of Interventions version 5.0). Meta-analysis was not possible because of the unique comparisons within each study. For this reason, the authors described individual studies instead of combining results through meta-analysis.

Summary of Main Results
• Surgical wounds that become infected are often debrided. Numerous methods are available but no consensus has been reached on which method is most effective for surgical wounds.
• One study reported that dextranomer achieved a clean wound bed significantly faster than EUSOL (Edinburgh University solution of lime), but the methodological quality was poor in this study.
• Another study that compared an enzymatic agent with saline-soaked dressings reported that the time required to achieve a clean wound bed was significantly shorter for the enzymatic group. However, the validity of the results is questionable because of the small sample size and the analysis of the data.

Nursing Implications
A number of study deficiencies reduced the confidence that the results of this study can be implemented in practice. These deficiencies include poor quality of the trials, small sample size, limited range of treatments, different control group for each study, lack of replication studies, and inappropriate statistical analysis. Additionally, 4 of the 5 RCTs compared the effectiveness of dextranomer beads or paste; however, as of 2007, use of dextranomer beads and paste was discontinued worldwide, except in South Africa, where paste only is available. The last RCT compared an enzymatic agent (streptokinase/streptodornase) with saline-soaked dressings, and streptokinase/streptodornase has also been discontinued worldwide.

Numerous dressings and types of debridement are available for wound care today, yet there is still a limited amount of high-quality published RCTs that evaluate debridement or compare different methods of debridement for surgical wounds available to guide clinical decision making. The choice of debridement method or agent should be guided by good evidence. More research on which method is most effective in removing dead tissue from surgical wounds that have become infected is clearly needed. CCN

Financial Disclosures
None reported.

Reference
Preventing Radial Artery Occlusion by Using Reverse Barbeau Assessment: Bringing Evidence-Based Practice to the Bedside

Colleen Bonnett, RN-BC, BSN
Nancy Becker, RN, MSN, CCRN
Brenda Hann, RN, MBA, CCRC
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Jennifer Tremmel, MD

The traditional approach to percutaneous coronary angiography and intervention (PCI) is by femoral artery access. However, in recent years, a paradigm shift has occurred in catheterization laboratories across the nation: transradial PCI. In 2007, only 1.3% of all PCIs done in the United States used the transradial approach. This percentage has now increased to more than 20%. This dramatic increase is chiefly due to higher patient satisfaction rates, reduced bed rest and recovery times, and a 78% lower risk for bleeding and vascular complications with transradial procedures than for the femoral approach.

Authors

Colleen Bonnett is a cardiac vascular certified nurse, currently the arrhythmia coordinator in the cardiology clinic at Stanford Health Care, Stanford, California.

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In 2008, the director of Women’s Heart Health, an interventional cardiologist, brought transradial PCI to our facility to offer patients, especially female patients, a safer PCI option. With femoral access, women have a higher risk of PCI bleeding complications than men have (2.86% vs 1.22%, P < .01). Transradial access reduces this risk to 1.1% for women and 0.67% for men. As of 2013, more than 30% of our facility’s PCIs are performed transradially (Figure 1). The importance of learning about both femoral and radial access has also expanded into periprocedural nursing. Nurses are required to incorporate evidence-based care for all patients before and after cardiac angiography and intervention. This article describes the nursing journey of identifying evidence-based best practices, developing education plans, and multiunit implementation of an important postprocedural assessment with transradial procedures, the reverse Barbeau test.

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Patent Hemostasis Beats Occlusive Hemostasis

Radial artery occlusion (RAO) is a complication of transradial PCI that occurs in 2% to 10% of patients. RAO can impede reaccess of the radial artery and future transradial procedures. In addition to impaired circulation, occlusion also decreases patients’ satisfaction and confidence in future treatment. In the PROPHET study, postprocedural occlusive hemostasis was the strongest predictor of RAO. Nurses can prevent radial site thrombus and RAO by ensuring patent hemostasis. Patent hemostasis provides enough pressure to stop the bleeding without occluding the vessel and is important beginning at sheath removal and continuing to discharge. The reverse Barbeau patent hemostasis test was recently listed as an evidence-based best practice by the Society for Cardiac Angiography and Interventions Transradial Working Group.

Preprocedure Barbeau Test Better Than Modified Allen Test

Normal circulation to the hand is supplied by both the radial and ulnar arteries, which communicate at the palmar arches (Figure 2). To be a candidate for a transradial procedure, patients must have sufficient ulnar circulation so that in the case of radial injury, the ulnar artery can provide collateral perfusion. Traditionally, the modified Allen test (MAT) was used to assess the quality of ulnar perfusion for patients having coronary artery bypass with radial artery access.
harvest. To perform this, the clinician occludes both radial and ulnar arteries, while the patient makes a tight fist until the hand blanches. The patient opens his or her hand and the clinician releases the ulnar artery compression and counts how long it takes for the patient's hand color to return to baseline. The MAT is dependent on the clinician’s subjective interpretation of “normal color” and can be difficult to perform on patients with darker skin.

The preprocedure Barbeau test is more sensitive and less dependent on the clinician’s subjective assessment because it uses a pulse oximeter finger probe with a plethysmography waveform, which can be objectively measured. After placing a pulse oximeter probe on the patient’s finger, the clinician observes the pulse waveform before and during radial artery compression, assesses waveform changes, and categorizes ulnar patency on the basis of an A, B, C, or D scale (Figure 3). In a 2004 study of 1010 patients, Barbeau et al reported that using the oximeter waveform to assess ulnar artery flow and palmar arch perfusion was less subjective than MAT and more inclusive of potential candidates. In that study, the Barbeau test excluded only 1.5% of the candidates from radial procedures compared with 6.3% excluded when the MAT was used.

**Best Practice for Patent Hemostasis:**

**Postprocedural Reverse Barbeau Test**

Postprocedural assessment of a radial access site requires assessment of circulation, sensation, movement, procedure incision, and any compression device in place. Palpating a radial pulse...
distal to the insertion site is not sufficient to confirm radial artery patency. Even with an occlusion, a radial pulse may still be palpated distally and can give a false-positive result for radial patency, owing to ulnar and palmar arch retrograde circulation (Figure 2). Best practice confirms radial patency by using the reverse Barbeau test.

The reverse Barbeau test is first performed after the radial sheath is removed and the hemostasis device is in place. The Terumo TR Band (Terumo Medical Corporation) is the hemostasis device used in our facility. The clinician places the pulse oximeter probe on the patient’s thumb on the procedure side and assesses the baseline oximetry waveform. The clinician then compresses the ulnar artery for no more than 2 minutes. The waveform that is seen during ulnar compression represents the quality of radial blood flow. The clinician then compresses the ulnar artery for no more than 2 minutes. The waveform that is seen during ulnar compression represents the quality of radial blood flow. The clinician categorizes waveform changes on the reverse Barbeau A, B, C, D scale (Figure 3). Using this assessment, the bedside nurse can continue to confirm radial artery patency without additional equipment or personnel and prevent RAO.

Taking Evidence-Based Practice to the Bedside

Our physician expert initiated the change by providing in-service training on transradial procedures and the reverse Barbeau test to the nurses in the catheterization laboratory. It was clear that the nurses needed to implement this change quickly to ensure patient safety and positive outcomes. The unit educator in the catheterization laboratory identified the need to include all hospital units that received transradial patients. Collaboration between unit educators and advanced practice nurses led to the development of a change plan. The change plan included education of nurses, changes in the electronic health record (EHR) flowsheet, revision of the procedure, and creation of guidelines (Figure 3). These changes crossed multiple units, inpatient and outpatient, to encompass all areas where transradial patients are seen.

The recovery nurses in the catheterization laboratory were the first phase of education and implementation. The procedure and competency were updated and the changes were shared with nurses from the catheterization laboratory through small-group instruction and individual return demonstration. Each pair of nurses took turns being the “patient” by placing a pulse oximetry probe on the “patient’s” thumb, with the TR band inflated on the radial artery. Next, the “nurse” palpated for a radial pulse. Almost every time, the radial pulse was palpable. After that, the “nurse” compressed the “patient’s” ulnar artery while watching for waveform changes and categorized according to the reverse Barbeau A, B, C, D scale.

The nurses reported benefiting from the hands-on demonstration of how a radial pulse may be palpated without true radial flow (category D). This training also gave nurses a unique opportunity to feel a little of what their patients feel: what it is like to wear a radial compression device and how it feels when it is on too tight. Nurses noted that the ulnar artery is sometimes difficult to occlude and were able to practice and improve their skills by using the waveform for immediate visual representation of occlusion.

The EHR updates needed to go through inpatient and outpatient informatics committees and required a work-around until changes were made. After the updates were completed, the nurses were able to chart the reverse Barbeau category under the radial artery circulatory assessment with a single click, making charting much easier. The charting included written descriptions of each category, as seen in Figure 3, and were identical for both inpatient and outpatient charting flowsheets.

After successful implementation in the recovery unit of the catheterization laboratory, unit educators from these periprocedure hospital units collaborated to standardize the education rollout for existing nurses and future hires. Creative uses of technology to advance training included use of the iPad (Apple Inc) to develop an instructional video that was embedded in a PowerPoint presentation. The video and presentation were used on multiple nursing in-service skills days for the different units. The video was uploaded to the hospital’s educational video network to be used for new hire orientation and review and can also be found at http://youtu.be/vcy_VRcKtEE. The hands-on practice with return demonstration was identical to the training given in the catheterization laboratory.
Competency demonstration of critical skills and knowledge completed the training. The transradial procedure was updated for both inpatient and outpatient units.

When patients undergoing a transradial procedure go from one unit to another, nursing handoff is a critical piece in ensuring patent hemostasis and safety. Nurses are instructed to communicate specific information with handoff, including the reverse Barbeau category and site assessment. The reverse Barbeau test is performed on arrival in the receiving unit, every hour while the compression device is on, and an hour after removal of the compression device to confirm continued patency of the radial artery. Reverse Barbeau category D signals a need to reduce compression in the radial hemostasis device. In this facility, the nurse reduces compression in small increments followed by a repeat reverse Barbeau test. If the patient bleeds at the site, the nurse increases compression as needed to regain hemostasis. After 15 minutes the nurse rechecks the reverse Barbeau test. If the result is still a category D, the nurse again attempts compression release in small increments followed by a reverse Barbeau reassessment. For continued category D, the nurse will communicate concern for RAO to the interventionalist.

This evidence-based project on patent hemostasis during radial artery access highlights advantages of multidisciplinary cooperation in accomplishing quality improvement. The interventionalist physician expert alerted nurses to the potential for improving outcomes with simple nursing assessments. Staff in the catheterization laboratory’s recovery and postprocedural units worked together to research literature, write guidelines, create educational materials, and change practice. Clinical informatics staff assisted in embedding the documentation and information on the reverse Barbeau category in the EHR. Being able to easily select the category from the circulatory assessment flowsheet made charting much easier. All current nurses and new hires in these units were educated on the change in practice. Since implementation of this practice, this facility has had no reports of radial artery occlusion during discharge or follow-up visit.

During the overall journey from discovery to implementation, fewer barriers were encountered than expected. The major barrier was finding time for staff education. The time invested in creating the video was time saved during nursing education. Having a premade PowerPoint presentation and video enabled a consistent and standardized approach to teaching.

Delays in the clinical informatics queue of jobs necessitated a charting work-around in the EHR during the initial stages. Adding additional nursing assessments was a perceived barrier because of the limited time available in the recovery room. This assessment proved to be very quick to perform and provided nurses with immediate feedback. Nurses are empowered to fix occlusion due to a hemostasis device applied too tightly.

Once nurses understood why a palpable radial pulse was not indicative of actual radial patency, nurse buy-in was immediate. After implementation of this assessment, nurses in the catheterization laboratory have seen category Ds (occlusive hemostasis) while still being able to palpate a radial pulse distal to the hemostasis device. This experience helped reinforce the need for the reverse Barbeau assessments.

With the increase in minimally invasive procedures, our nursing care and assessments also need to advance. The reverse Barbeau test is a necessary assessment to provide evidence-based nursing care for patients undergoing procedures that involve radial access.

This implementation of evidence-based practice across multiple units and disciplines illustrates the power of collaboration. Improving patients’ outcomes is a priority for all members of the health care team. Nurses can find creative solutions to bring the health care team together in providing evidence-based practice to improve patient care. CCN

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Hemodynamic Monitoring: Evolving Technologies and Clinical Practice

Reviewed by Linda Bell, RN, MSN

Invasive hemodynamic monitoring has been present in the intensive care unit since the early use of central venous pressure catheters for monitoring fluid volume and mercury manometers for measuring pressures via arterial catheters. Technology, scientific advances, and translational research have brought many changes from those early years, including less invasive methods that require different knowledge and competencies. However, nurses must still understand the physiologic principles of flow, pressure, and resistance to be able to interpret the multitude of data that exist in their environment.

Hemodynamic Monitoring contains 3 parts: a discussion of monitoring methods, advancing technologies that change how we are monitoring, and the application of this information to practice. The book begins with Fundamentals of Hemodynamic Monitoring and Physical Assessment and Hemodynamic Monitoring. These 2 chapters provide the foundation for the following chapters.

Each chapter includes multiple learning and teaching tools. In addition, case studies review and discuss the content of each chapter. The many boxes and figures provide easy access to resources, data, and calculations that guide patient management. Each chapter also includes Clinical Reasoning Pearls that highlight the key concepts for the reader. The addition of Patient Education, Patient Safety, and Patient Comfort components to these chapters reminds us that all the knowledge and competency are directed to achieve positive outcomes for and with our patients.

New technologies addressed by the advances section include Doppler, ultrasonography-based, arterial waveform, and pressure-based monitoring, as well as implantable monitoring. These methods are important for managing fluid responsiveness, and ultrasound-based monitoring is now included as a strategy in the management of sepsis.

The third section of clinical applications considers issues of mechanical ventilation and acute respiratory distress syndrome, mechanical circulatory support, management of cardiac surgery patients, use of hemodynamic management in heart failure and shock, right heart failure and pulmonary hypertension, hypovolemia and trauma, and sepsis. Uniquely, this volume includes hemodynamic and intracranial dynamic monitoring in neurocritical care and goal-directed hemodynamics. All of these clinical scenarios describe issues that confound care providers. As the population ages and presents with multiple comorbidities, these issues become more and more complex to manage.

It has been many years since there has been a comprehensive volume on the topic of hemodynamic monitoring that is also a good read. This book is important for any nurse’s library. One can hope that this book will continue to be updated as necessary to meet the changing technology and patient needs.
Ethics has been an integral part of nursing since the early beginnings of our profession. The first nursing code of ethics, A Code for Professional Nurses, was formally adopted by the American Nurses Association (ANA) in 1950. Much has changed in the health care environment since then, but the responsibility of nurses to act in an ethical manner has not.

This 2015 edition is a revision of the 2001 Code of Ethics for Nurses With Interpretive Statements. The purpose of this update was to review and incorporate any changes in health care and clinical practice. A steering committee was convened for the revision, representing various nursing roles, practice settings, and geographical areas across the United States. ANA has been working on this update for 4 years, starting with an online public survey leading to the first revision, which was then posted for public comment. All of these comments were considered when completing the revision.

The Code of Ethics for Nurses With Interpretive Statements still has 9 provisions articulating the fundamental values and commitments of nurses, boundaries of duty and loyalty, and duties of nursing beyond individual patient interactions. The Interpretive Statements are still included to provide context and guidance for practice within an ever-changing health care environment.

Important changes are included in this revision. First is the addition of a glossary to ensure that all readers have a common understanding of the terminology used in the book. Also, an introduction helps to orient the reader to the content and purpose of the document as well as to the rationale for wording decisions such as the continued use of “patient” rather than the term “client.” Finally, the online version includes links to seminal documents that support the role of ethics within the practice of nursing.

The Code of Ethics for Nurses With Interpretive Statements should be a part of every nurse’s library. This document helps us frame our practice when answering the confusing ethical questions that arise in everyday practice, no matter what the role in nursing or health care. It is the accountability of all nurses to incorporate these provisions and maintain the trust that our patients and society has placed in nursing.

CCN

Linda Bell is a clinical practice specialist at the American Association of Critical-Care Nurses in Aliso Viejo, California.
New Products

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*For more information, visit www.novabiomedical.com.*
California
Sacramento
CCRN/PCCN Review
Date: September 15-16, 2015. Place: University of California Davis, Education Building. Address: 416 X St, Sacramento, CA. Sponsor: Sacramento Area Chapter of AACN. Keynote Speaker: Carol Rauen. Contact: Laura Tobin. Phone: (916) 781-1651. E-mail: tobso4@hotmail.com. Fee: TBD. 2-day course. Reduced parking $6.

Colorado
Denver
CCRN and PCCN Certification Review Course
Date: November 18-20, 2015. Place: University of Colorado Hospital, Bruce Schroffel Auditorium, Denver, CO. Sponsor: Denver Chapter of AACN. Keynote Speaker: Carol Rauen. Contact: Shannon Johnson Bortolotto. E-mail: shannon.bortolotto@uchealth.org. Fee: Early bird $195 through 9/1/15; $225 after 9/2/15; $125 per day.

Louisiana
New Orleans
Pediatric Critical Care Nursing

Nevada
Las Vegas
Certification in Legal Nurse Consulting (5-day seminar and online)

Pennsylvania
King of Prussia
2015 TRENDS in Critical Care Nursing Conference
Date: October 6-9, 2015. Place: Valley Forge Event Center. Address: 1160 First Ave, King of Prussia, PA 19406. Sponsor: Southern Pennsylvania (SePA) Chapter of AACN. Keynote Speakers: Clareen Wiencek, Tracy Carlino, Charles Kunkle, Al Rundio. Contact: Patricia Nicols. E-mail: sepaeducation@sepa-aacn.org. Credits: 16 CEUs

Texas
Dallas
Advanced Critical Care & Emergency Nursing
Date: November 1-4, 2015. Place: Hilton Dallas Lincoln Centre. Sponsor: Contemporary Forums. Contact: Kristine Mulholand. Address: 3478 Buskirk Ave, #242, Pleasant Hill, CA 94523. Phone: (800) 377-7707. Fax: (925) 828-1950. E-mail: info@cforums.com. Website: contemporaryforums.com. Credits: 16 CEUs

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I Am a Critical Care Nurse

Alisha Burnett, RN, is a staff nurse in the surgical trauma intensive care unit at Tampa General Hospital, Tampa, Florida.

Why did you become a nurse?
I lost a very close friend to burn injuries in 2006. The nurse who cared for him inspired me to want to help families in their worst times. That summer I was accepted to the nursing program and began my journey to becoming a nurse.

What about your job as a nurse makes you happy?
Knowing that I truly make a difference in people’s lives makes me happy. The most exciting part of being a critical care nurse is the adrenaline rush in critical situations. The critical thinking and smooth working of a medical team in action are so impressive.

Tell us about an extraordinary experience you’ve had as a critical care nurse.
As a flight nurse in New York, I once accompanied a patient who was burned on more than 60% of his body. Because I didn’t know if he would survive, I made sure his family could spend time at his bedside before we flew him to another hospital. I knew what it felt like to have a loved one with severe burn injuries, and I knew how hard it had been for me. Two months after the patient’s accident I was invited to a dinner to honor his care team. I saw how well he was doing and I met his family again. I have a picture of us that I hold close to my heart. I still keep in touch with all of them.

What are the challenges you encounter and how do you overcome them?
I think the emotional aspect of being a nurse is the most difficult part of my job. As critical care nurses, we’re trained to leave work at the door when we end our shift. Sometimes we have patients who really have an effect on us, and it’s hard to leave that at work. I overcome this challenge by reminding myself why I entered the field. Knowing I’m helping my patients and their families is what keeps me going.

What has your journey as a nurse been like?
Exhilarating! I’ve had the opportunity to work in 2 level I hospitals, in 2 burn intensive care units and 2 trauma intensive care units, and as a critical care transport flight nurse. I’ve learned so much and gained so much experience in such a short time. I feel incredibly blessed.

At the end of a busy day, how do you find balance in your life?
I’m not sure I ever feel “balanced,” but coming home to a wonderful husband and 3 furry children (a German shepherd, a puggle, and a cat) brings me back down to a level place. My husband is also a critical care nurse, so it’s nice to be able to talk to him if I’ve had a bad day.

What would we be surprised to know about you?
I never wanted to be a nurse because I didn’t think I had the stomach for it. When friends said they wanted to go into the medical field, I told them they were crazy! I have a degree in English because I was pursuing a career in education before beginning nursing school.

How has AACN played a role in your career?
AACN has pushed me to become the best nurse I can be, from passing the CCRN examination to the hundreds of continuing education credits I’ve worked for through AACN. The knowledge base I’ve gained from these 2 AACN benefits never ceases to amaze me. CCN

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