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Take care when prescribing, preparing, and administering OFIRMEV Injection to avoid dosing errors which could result in accidental overdose and death. In particular, be careful to ensure that:

- the dose in milligrams (mg) and milliliters (mL) is not confused;
- the dosing is based on weight for patients under 50 kg;
- infusion pumps are properly programmed; and
- the total daily dose of acetaminophen from all sources does not exceed maximum daily limits.

OFIRMEV contains acetaminophen. Acetaminophen has been associated with cases of acute liver failure, at times resulting in liver transplant and death. Most of the cases of liver injury are associated with the use of acetaminophen at doses that exceed the recommended maximum daily limits, and often involve more than one acetaminophen-containing product.

INDICATIONS AND USAGE
OFIRMEV® (acetaminophen) injection is indicated for the management of mild to moderate pain, management of moderate to severe pain with adjunctive opioid analgesics, and reduction of fever.

IMPORTANT RISK INFORMATION

Please see additional Important Risk Information and Brief Summary of Full Prescribing Information, including complete boxed warning, on the following pages.
In a major abdominal and pelvic surgery study, patients receiving IV acetaminophen 1 g with IV opioids (n=20) reported significantly lower pain scores vs placebo with IV opioids (n=20), \(P<0.01\).

The efficacy of OFIRMEV® (acetaminophen) injection has been proven in multiple settings.\(^1-5,7-16\) For more information, visit OFIRMEV.com.

The clinical benefit of reduced opioid consumption with OFIRMEV has not been evaluated or demonstrated.

Percentage of patients, after total hip replacement, rating satisfaction as “good” or “excellent” at bedtime improved\(^6,a\)

Following hip arthroplasty, 85.7% of patients receiving OFIRMEV with PCA morphine (n=30) vs 39.3% of patients receiving placebo with PCA morphine (n=31) reported “good” or “excellent” satisfaction with their pain management at bedtime, \(P=0.0018\).

\(^a\) This study was terminated early due to detection of particulates in some placebo vials.
INDICATIONS AND USAGE

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CONTRAINDICATIONS

- Acetaminophen is contraindicated in patients with:
  - known hypersensitivity to acetaminophen or to any of the excipients in the intravenous (IV) formulation.
  - severe hepatic impairment or severe active liver disease.

WARNINGS AND PRECAUTIONS

- Administration of acetaminophen in doses higher than recommended may result in hepatic injury, including the risk of liver failure and death. Do not exceed the maximum recommended daily dose of acetaminophen. The maximum recommended daily dose of acetaminophen includes all routes of acetaminophen administration and all acetaminophen-containing products administered, including combination products. Dosing errors could result in accidental overdose and death.

- Use caution when administering acetaminophen in patients with the following conditions: hepatic impairment or active hepatic disease, alcoholism, chronic malnutrition, severe hypovolemia (e.g., due to dehydration or blood loss), or severe renal impairment (creatinine clearance ≤ 30 mL/min).

- Rarely, acetaminophen may cause serious skin reactions such as acute generalized exanathematous pustulosis (AGEP), Stevens-Johnson Syndrome (SJS), and toxic epidermal necrolysis (TEN), which can be fatal.

- Hypersensitivity and anaphylaxis associated with the use of acetaminophen have been reported. Clinical signs included swelling of the face, mouth, and throat, respiratory distress, urticaria, rash, and pruritus.

- The antipyretic effects of OFIRMEV may mask fever.

ADVERSE REACTIONS

- Serious adverse reactions may include hepatic injury, serious skin reactions, hypersensitivity, and anaphylaxis.

- Common adverse reactions in adults include nausea, vomiting, headache, and insomnia. Common adverse reactions in pediatric patients include nausea, vomiting, constipation, pruritus, agitation, and atelectasis.

USE IN SPECIFIC POPULATIONS

- Pregnancy Category C. OFIRMEV should be given to a pregnant woman only if clearly needed.

- Breastfeeding: While studies with OFIRMEV have not been conducted, acetaminophen is secreted in human milk in small quantities after oral administration.

- Pediatric Use: The effectiveness of OFIRMEV for the treatment of acute pain and fever has not been studied in pediatric patients < 2 years of age.

To report SUSPECTED ADVERSE REACTIONS, contact Mallinckrodt Hospital Products, Inc. at 1-800-778-7898 or the FDA at 1-800-FDA-1088 or www.fda.gov/medwatch.

Please see Brief Summary of Full Prescribing Information, including complete boxed warning, on the following page.

References:

**INDICATIONS AND USAGE**

OFIRMEV® (acetaminophen) injection is indicated for:

- the management of mild to moderate pain
- the management of moderate to severe pain with adjunctive opioid analgesic
- the reduction of fever.

**DOSEAGE AND ADMINISTRATION**

**General Dosing Information**

OFIRMEV may be given as a single or repeated dose for the treatment of acute pain or fever. No dose adjustment is required when switching between acetaminophen and OFIRMEV in adults and adolescents who weigh 50 kg and above. Caution should be exercised when switching between acetaminophen and OFIRMEV in patients on all routes of administration, i.e., intravenous, oral, and rectal and all products containing acetaminophen. Exceeding the maximum recommended dose of 15 mg/kg in adults and adolescents weighing 50 kg and below or 650 mg every 4 hours, with a maximum single dose of 1,500 mg or 5,000 mg every 24 hours, may result in hepatic injury, including the risk of liver failure and death. To avoid the risk of overdose, ensure that the total amount of acetaminophen from all routes and from all sources does not exceed the maximum recommended dose.

**Recommended Dosage: Adults and Adolescents**

Adults and adolescents weighing 50 kg and over: the recommended dosage of OFIRMEV is 1,000 mg every 6 hours or 125 mg/kg every 4 hours, with a maximum single dose of 1,500 mg or 5,000 mg every 24 hours. A maximum minimum interval of 4 hours, and a maximum daily dose of 6,000 mg in 24 hours, are recommended for the intravenous infusion. Each 100 mL glass vial contains 1000 mg of acetaminophen (10 mg/mL) as a free, isotonic formulation of acetaminophen intended for intravenous infusion. Place each 100 mL glass vial containing 1000 mg of acetaminophen in order to avoid dosing errors. The maximum recommended daily dose (MRDD) of acetaminophen in adults and adolescents is 4 grams/day, based on a body surface area comparison. In a case report of a 24-year-old woman who had received 4 grams/day of OFIRMEV over 15 years, the maximum daily dose of acetaminophen from all sources does not exceed the maximum recommended dose.

**Drug Interactions**

Acetaminophen is contraindicated in patients with severe hepatic impairment or severe active liver disease (see Warnings and Precautions [5.1]).

**WARNINGS AND PRECAUTIONS**

Administration of acetaminophen in dosages higher than recommended may result in hepatic injury, including the risk of liver failure and death (see Overdosage [10]). Do not exceed the maximum recommended daily dose of acetaminophen (see Dosage and Administration [2.3]) and maximum daily dose of OFIRMEV (1,000 mg every 6 hours and 125 mg/kg every 4 hours). The maximum recommended daily dose of acetaminophen includes all acetaminophen-containing products administered, including combination products.

**USAGE IN SPECIFIC POPULATIONS**

**Geriatric Use**

There have been post-marketing reports of hypernatremia and hyperglycemia associated with the use of acetaminophen. Clinical signs included swelling of the face, mouth, and throat, respiratory distress, urticaria, rash, and pruritus. There were reports of life-threatening anaphylaxis requiring emergent medical attention. Discontinue OFIRMEV immediately if symptoms associated with allergy or hypersensitivity occur. Do not use OFIRMEV in patients with acetaminophen allergy.

**ADVERSE REACTIONS**

The following serious adverse reactions are discussed elsewhere in the labeling:

- Hypersensitivity (see Warnings and Precautions [5.2])
- Severe Skin Reactions (see Warnings and Precautions [5.2])
- Allergy and Hypersensitivity (see Warnings and Precautions [5.2])

**Clinical Trial Experience**

Clinical trials were conducted under widely varying conditions, adverse reaction rates observed cannot be directly compared to rates in other clinical trials or may not reflect the rates observed in clinical practice.

**Drug Interactions**

OFIRMEV can cause fetal harm when administered to a pregnant woman only if the benefit outweighs the risk. The results from a large population-based prospective cohort, including data from 26,244 women with live-born singlets who were exposed to acetaminophen during the first trimester, conclude no increased risk for congenital malformations, congenital anomalies, or developmental delays. Male offspring of exposed pregnant women. The rate of congenital malformations (4.9%) was similar to the rate in the general population. A population-based, case-control study from the National Birth Defects Prevention Study showed that 11,610 children with prenatal exposure to acetaminophen were no more likely than children of unexposed parents to have any defects compared to 4,500 children in the control group. Other studies also had similar results.

While animal reproduction studies have not been conducted with intravenous acetaminophen, studies in pregnant rats that received oral acetaminophen during organogenesis showed no effect on fetal weight or survival up to 0.8 times the maximum human daily dose (MHDD) = 4 grams/day, based on a body surface area comparison. A dose-related reduction in body weight of fetuses and litter size was observed in an embryo-fetal toxicity study in rats; fetal body weight was reduced, and litter size was reduced in high-dose pregnant rats. Fetal no maternal body weight gain and litter size were reduced and litter size was reduced in high-dose pregnant rats. Fetal body weight was reduced, and litter size was reduced in high-dose pregnant rats. Fetal body weight was reduced, and litter size was reduced in high-dose pregnant rats. Fetal body weight was reduced, and litter size was reduced in high-dose pregnant rats. Fetal body weight was reduced, and litter size was reduced in high-dose pregnant rats.
Progressive Care Nurses Improving Patient Safety by Limiting Interruptions During Medication Administration

Fran Flynn, Julie Q. Evanish, Josephine M. Fernald, Dawn E. Hutchinson, and Cheryl Lefaiver

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Medical News Headlines: Don’t Believe Everything You Read

When so much distraction bombards our senses every waking hour, it’s not surprising that visual and auditory images often border on the extreme or outrageous to be eye-catching or that headlines, in their competition for our diminishing attention to print media, often resemble those formerly reserved for the tabloid press. When everyday news is presented in this sensationalist manner by television networks that launch every broadcast with “breaking news” that is often neither, news anchors heavily emoting on potholes, traffic reporters describing normal tie-ups as if these were mass evacuations, and meteorologists breathlessly forecasting warnings about carrying an umbrella, we grow accustomed to it. When health care news is conveyed in a comparable manner, however, it can represent a jarring and confusing departure from our more accustomed tone of professional narrative and diminish trust in its source.

Two health care headlines snagged my attention recently after they were repeated in various locations over the course of a few months. The gist of these headlines was as follows:

- Patient survival is better when cardiopulmonary resuscitation (CPR) is performed by bystanders rather than (emergency medical services) EMS personnel.
- Medical errors are the third-leading cause of death in the United States.

Neither of these announcements seemed plausible. The first seemed to suggest that untrained laypersons who encounter someone in cardiac arrest somehow perform CPR more effectively than highly trained health care providers. The second headline suggested some form of physician-led national pandemic of medical misadventure that was precipitating widespread patient demise. Both demanded follow-up to determine their validity and supporting evidence.

Patient Survival Is Better When CPR Is Performed by Bystanders Compared to EMS

I first noticed this banner at Medscape, where a summary explained it was based on 2 studies that appeared in a July 2015 issue of the *Journal of the American Medical Association*. In the first report, researchers in North Carolina examined 4961 patients in the Cardiac Arrest Registry to Enhance Survival who had experienced out-of-hospital cardiac arrest (OHCA) and for whom resuscitation had been attempted by bystanders or first responders (firefighters, police, others trained in basic life support) before arrival of EMS personnel. Before the study (2010-2013), statewide instruction was provided to improve bystander and first responder contributions to team-based CPR, apply high-performance CPR, and use automated external defibrillators (AEDs). Findings demonstrated that the greatest OHCA survival (to discharge) rate (33.6%) was achieved when CPR and defibrillation were both provided by bystanders; the lowest survival rate (15.2%) was associated with EMS-initiated CPR and defibrillation. In addition, improved survival with favorable neurological
outcomes was only achieved when CPR was bystander-provided. When CPR and defibrillation were provided by first responders, 25.2% survival was achieved; bystander CPR with first-responder defibrillation was associated with 24.2% survival.

A second study in Japan produced similar outcomes by examining data generated over 8 years (2005-2012) with a much larger sample (nearly 168 000) from the national registry who experienced bystander-witnessed OHCA. Findings revealed that bystander chest compressions was associated with a doubling of the neurologically intact survival rate (8.4%) compared to victims not receiving bystander CPR (4.1%). Bystander-only defibrillation was associated with higher neurologically intact survival of 40.7% compared to 15% when defibrillation was EMS only.

What is evident from both studies is the beneficial influence that bystander CPR and defibrillation have on both survival and neurologically intact survival following OHCA. What is not evident to anyone who just reads the first headline is the following:

- The survival rate (to hospital discharge) from OHCA remains dismal in most locations in the world, including the United States where it averages 10.6%, so doubling or tripling that rate is noteworthy.

- When OHCA includes bystander-witnessed ventricular fibrillation, survival increases to 38.6% for patients of any age, while it improves to only 12% for EMS-treated OHCA with any first recorded rhythm.

- In the North Carolina study, “bystanders” were not just anyone but people who witnessed the arrest and had received instruction on cardiac arrest recognition, CPR, and AED use.

- The crucial variable for patient survival from OHCA is not (as the headline would suggest) the provider (bystander vs EMS), but time: bystanders initiate CPR and defibrillation immediately following OHCA rather than after the time delay necessary for EMS to arrive at the scene.

- The magnitude of that time delay also seems to explain the 3-tiered survival improvement:
  - Highest associated with bystanders’ immediate responses
  - Intermediate with first-responders who arrive later
  - Least with EMS who arrive latest, when cardiac output compromised longest, resulting in anoxia and end-organ damage that may render ventricular tachycardia or fibrillation into a pulseless dysrhythmia no longer amenable to defibrillation.

- Further evidence of the primacy of time in OHCA survival is illustrated in Seattle, Washington, which boasts a 62% survival rate from witnessed cardiac arrests, described as the highest in the world. Factors contributing to that achievement include 69% of OHCA victims receiving bystander CPR, large numbers of the population trained in CPR, extensive network of AEDs, and rapid response times that average 7.5 minutes (4.32 urban areas, 5.54 suburban, 7.0 rural, 10.4 wilderness).

Medical Errors Are Now the Third-Leading Cause of Death in the United States

In May 2016, a paper announcing “Medical error—the third leading cause of death in the US” was published in The BMJ. When I investigated the evidence for this provocatively titled paper, I found not a research report, but more an essay advocating revision of death certificates to include factors associated with medical errors, a brief literature review asserting that the Institute of Medicine’s (IOM’s) projection of 98 000 annual deaths from medical errors was an outdated underestimate not based on primary research, citation of even older and some newer projections ranging from 140 400 to more than 400 000, a single sentence describing their own extrapolated calculation from pooled preexisting data (251 454 annually), and suggested approaches to the problem. The analysis defined medical error as any unintended individual or system level act that may or may not cause harm. The authors’ procedure examined 4 studies reported between 2000 and 2008, then extrapolated to the total number of US hospital admissions in 2013. There was no description of the logic or statistical basis for this projection.

As one might expect, an analysis quadrupling the admittedly dated yet alarming IOM estimate precipitated a number of responses from health care professionals, some of whom supported the conclusion, while many others disagreed with the procedures, estimate, and conclusion.

What is evident from the headline is that errors in any aspect of health care services remain a concerning and compelling problem within the field and that better means of measuring these could assist in their prevention. What is not evident to anyone who just reads the
headline can be identified from some of the recurring themes in responses to this paper:

- Reader comments at The BMJ website expressed a range of concerns: the paper used inconsistent definitions of events in operationalizing the errors to count, classified all adverse events as preventable without any evidence to do so, calculated only in-hospital events while the conclusion extended across all of health care. Some called for retraction (comparable to returning toothpaste to its tube this late after dissemination).

- A National Public Radio interview related that the Centers for Disease Control’s chief of mortality statistics disputed that coding is the problem, saying that complications from medical care are listed and can be coded, and a physician who participated in the IOM report said existing estimates lack the precision necessary for listing errors as the third-leading cause of death.

- At the Medscape website, physicians acknowledged the problem and need to minimize medical errors, but took issue with the authors’ sweeping definition of medical error, especially its neglect to distinguish among actual errors, complications, unavoidable complications, and disappointing results; noted that “medical” denotes physicians when many other providers and workers affect patient care; indicted the methods used for analysis, as well as the use of hyperbole, fear-mongering, and sensationalism to address an important issue.

Other Concerns Related to Sensationalism in Medical Headlines

Among the reader responses to this paper, one surgeon accused the authors of “fishing for funding” with such hyperbole. So how would that work? Create a few scary health care statistics, write some attention-grabbing conclusions that strike fear in the population, get your name, fame, and tons of free international media coverage all over the Internet and news outlets, reinforce the need for elected officials to “do something about it,” and await priority research funding as the public voice for resolving the problem. Cynical? Maybe or maybe not.

One of the items I ran across in researching this paper was a Washington Post interview with the authors, who related that they conducted the analysis “to shed more light on a problem that many hospitals and health-care facilities try to avoid talking about.” Although that intention sounds noble, it contrasted markedly with the origin identified with the actual article, relating that the paper “arose from discussions about the paucity of funding available to support quality and safety research relative to other causes of death.” The latter certainly sounds like an admission that the surgeon’s suspicion regarding “fishing for funding” was not misplaced.

The potentially biasing influence of financial gain can be delivered through various means and locations. Just like medical error, financial gain may exist at individual or system levels. Research funding may be directed to one’s institution, department, and a research program, whereas financial gains such as royalties from book sales may benefit an individual directly. For example, in the course of examining materials related to this paper, I noted 2 instances where different books related to the topic and written by the first author are mentioned or advertised.

Despite the legitimacy of the underlying issue of medical errors and whatever staggering prevalence is true, I do not think there is any place for even the appearance of authors having financial gain related to a position they take on health care issues nor any place for blatantly advertising tell-all products related to their claims. I find this type of journalism troubling as it not only reflects poorly on our ethics and professionalism, but distracts from the more important need to inspire studies that confirm or refute such findings based on sound science, not on inflating one’s research budget or book royalties.

Closing

As both contributors to and consumers of news related to the health care industry, these examples illustrate why critical care nurses need to always read beyond the headlines to examine the quality and breadth of evidence that exists for their support. A tentative, skeptical attitude is particularly warranted when headlines ascribe momentous benefit or ill to a single cause. Very little in life or health or death is fully attributable to a single cause, so a critical eye and a healthy dose of skepticism are useful tools for vetting such claims.
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Challenges Caring for Adults With Congenital Heart Disease in Pediatric Settings: How Nurses Can Aid in the Transition
Kristin Anton, RN, BS, BSN, CPNP-AC

As surgery for complex congenital heart disease is becoming more advanced, an increasing number of patients are surviving into adulthood, yet many of these adult patients remain in the pediatric hospital system. Caring for adult patients is often a challenge for pediatric nurses, because the nurses have less experience and comfort with adult care, medications, comorbid conditions, and rehabilitation techniques. As these patients age, the increased risk of complications and comorbid conditions from their heart disease may complicate their care further. While these patients are admitted on a pediatric unit, nurses can aid in promoting their independence and help prepare them to transition into the adult medical system. Nurses, the comprehensive medical teams, and patients’ families can all effectively influence the process of preparing these patients for transition to adult care. (Critical Care Nurse. 2016;36[4]:e1-e8)

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Notice of Retraction
The April 2016 issue of Critical Care Nurse included the online publication of 2016 National Teaching Institute Evidence-Based Solutions Abstracts. One of these abstracts, EB 56: Improving Outcomes With Low-Fidelity Simulation in Annual Competency Training, by Sofia Puerto (2016;36[4]:e22), is hereby retracted by the publisher in accordance with the wishes of the institution where the project was performed. The project was not current and should not have been presented as current.

The author agrees to the retraction of the abstract.

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doi: http://dx.doi.org/10.4037/ccn2016665
Letters to the Editor

The Rippling of “The Pause”

The Pause, an article in the February 2014 issue (Critical Care Nurse. 2014;34[1]:74-75) by Jonathan Bartels, presents a concept that can be used to set a culture of caring and nurturing for patients, their family, and staff. The concept, called The Pause, is a simple time out, 45 seconds to about 1 minute, that recognizes a patient’s death as well as the efforts of the clinical staff when, despite all interventions, the patient dies. This concept, according to Bartels, is not brain surgery or rocket science, but a method for comforting and healing.

Hospitals do not need an educational roll-out or check-off list to begin to implement The Pause. Bartels says to just do it; start implementing The Pause right away and begin the healing of taking care of yourself and others on the team.

Many departments and disciplines are involved in code blues, including laboratory, radiology, pharmacy, physicians, nurses, technicians, chaplains, respiratory therapists, and paramedics; the list goes on and on. Compassion fatigue can affect those working in health care. It is described as the medical professionals’ posttraumatic stress disorder. Seeing death, trauma, unimaginable injuries, sorrow, and pain on a daily basis can take a toll on human beings and can be emotionally draining. Holding the hand of a patient who is scared, dying, or in pain will catch up with you if you do not take care of yourself and figure out how to deal with your feelings.

One way health care workers can intentionally take care of themselves is to implement The Pause. For just a short time, pause and acknowledge what has occurred and recognize that you did the very best you could. Give yourself and your team grace and honor the life that has slipped away. After The Pause you will be more ready to move on to your next task and to recognize that life can be treasured and enjoyed.

Bartels, who at the time was an emergency room nurse and palliative care liaison, started The Pause at the University of Virginia Medical Center in the emergency department. The concept and the practice of The Pause spread throughout that hospital.

After The Pause was published in Critical Care Nurse, the concept began spreading across the United States. In fact, Bartels has received communication that The Pause has spread to other parts of the world, including Australia and Paraguay. This is tremendous!

At the National Teaching Institute & Critical Care Exposition 2014 in Boston, the American Association of Critical-Care Nurses President, Vicki Good, spoke about The Pause. Good reminded critical care nurses that often when we need to be intentional about pausing in our work is when we feel as if we do not have the time or we are not intentional about it. Speaking to this audience yielded great support and encouragement for implementing The Pause in many institutions throughout the United States.

After reading Bartels’ article and hearing Good speak, I stepped forward and told anyone and everyone who would listen about The Pause. Now I would like to share how we are “pausing” in New Mexico.

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After reading Bartels’ article and hearing Good speak, I stepped forward and told anyone and everyone who would listen about The Pause. Now I would like to share how we are “pausing” in New Mexico.

We started by sharing the concept of The Pause with our hospital administrator, Angela Ward, RN, MSN. She encouraged me to share the information in our department manager meeting, which leaders from all units in the hospital attend. Those leaders at Presbyterian Rust Medical Center in Rio Rancho, New Mexico, immediately embraced the concept and we implemented it the next day in our
emergency department. It was that important and that easy.

The response from physicians has blown me away. The first time The Pause was implemented in the emergency department, I thought the emergency department physician would excuse himself and say he was busy, but he did not. He gave me a nod and stood at the bedside in reverence.

The word spread to our sister hospital downtown in Albuquerque and I was asked to share The Pause with them. In fact, it was so well received I have been asked to share this information on many other occasions. Similar to my hospital where the results have been overwhelmingly positive, the excitement voiced by many of the units from our sister hospital has been rewarding.

It should be noted, in case you have not read the original article yet, that this is not a religious ritual. It is simply a moment, a pause, to honor the life that has slipped away and to honor our efforts to do what we could to preserve life.

After the word rippled among nurses in Albuquerque, I was honored to present The Pause at the Transforming Care at the Bedside Annual Conference to nurses from all over the state. Their feedback was very positive.

At Presbyterian Rust Medical Center we now include The Pause in our monthly hospital employee orientation, which includes staff from respiratory therapy, laboratory, nursing, pharmacy, radiology, chaplains, paramedics, and more.

Thank you Jonathan for this wonderful article and initiative that I will continue to talk about for years to come. One thing I say when talking about The Pause is how beautifully you wrote the article. Your words touched my heart and changed me.

As a critical care nurse, hospital supervisor, and member of the rapid response team, I have always tried to take extra time with dying patients and their families, but it never seemed like it was enough. However, with The Pause, we enhance not only the care we take of ourselves but also we show families respect for their loved ones in a significant way. This idea is just so awesome and it has made a difference in my practice and in my team’s practice. CCN

Angie Greer, RN, BSN, CCRN
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Progressive Care Nurses
Improving Patient Safety by Limiting Interruptions During Medication Administration

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Julie Q. Evanish, RN, BS, PCCN
Josephine M. Fernald, RN, BSN, PCCN
Dawn E. Hutchinson, RN, BSN, PCCN
Cheryl Lefaiver, RN, PhD, CCRP

BACKGROUND
Because of the high frequency of interruptions during medication administration, the effectiveness of strategies to limit interruptions during medication administration has been evaluated in numerous quality improvement initiatives in an effort to reduce medication administration errors.

OBJECTIVES
To evaluate the effectiveness of evidence-based strategies to limit interruptions during scheduled, peak medication administration times in 3 progressive cardiac care units (PCCUs). A secondary aim of the project was to evaluate the impact of limiting interruptions on medication errors.

METHODS
The percentages of interruptions and medication errors before and after implementation of evidence-based strategies to limit interruptions were measured by using direct observations of nurses on 2 PCCUs. Nurses in a third PCCU served as a comparison group.

RESULTS
Interruptions ($P < .001$) and medication errors ($P = .02$) decreased significantly in 1 PCCU after implementation of evidence-based strategies to limit interruptions. Avoidable interruptions decreased 83% in PCCU1 and 53% in PCCU2 after implementation of the evidence-based strategies.

CONCLUSIONS
Implementation of evidence-based strategies to limit interruptions in PCCUs decreases avoidable interruptions and promotes patient safety. (Critical Care Nurse. 2016;36[4]:19-35)

Nurses play a critical role in promoting patient safety through surveillance and interception of errors that cause patient harm as hospitals and health care systems strive to become high-reliability organizations.1 The Institute of Medicine estimates that medication errors result in several thousand deaths annually.2 Interruptions during complex or high-risk activities such as medication administration increase risk of errors.

This article has been designated for CE contact hour(s). The evaluation tests your knowledge of the following objectives:
1. Describe similarities between the principles of the sterile cockpit concept used in the aviation industry and the Nurses Uninterrupted Passing Medications Safely (NUPASS) guidelines to promote safety.
2. Discuss the current evidence supporting use of interruption limiting strategies to reduce medication administration errors in the acute care setting.
3. Implement evidence-based strategies to limit interruptions during medication administration.

To complete evaluation for CE contact hour(s) for test #C1642, visit www.ccnonline.org and click the “CE Articles” button. No CE test fee for AACN members. This test expires on August 1, 2019.

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Josephine M. Fernald was a bedside nurse in one of the progressive cardiac care units at the time of the project and is now working in the outpatient heart failure clinic, Advocate Christ Medical Center.

Dawn E. Hutchinson was a bedside nurse in a progressive cardiac care unit when the study was done and is now a clinical informatics specialist, Advocate Christ Medical Center.

Cheryl Lefaiver was the professional nurse researcher for the medical center when the study was done and is now manager of patient-centered outcomes research for Advocate Center for Pediatric Research, Advocate Christ Medical Center.

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Background
In a plenary speech at the 2008 National Teaching Institute, the former president of the American Association of Critical-Care Nurses challenged more than 9000 nurses in attendance to avoid multitasking and interruptions when administering medications in order to prevent medication errors.

Attendance at the National Teaching Institute was the inspiration for this project and the springboard for addressing existing nursing concerns about interruptions.

Attendance at this speech was the inspiration for this project and became the springboard for addressing existing nursing concerns about interruptions.

Review of the Literature
Observational studies describe the high cognitive work of nurses coupled with frequent interruptions and multitasking behaviors during direct patient care activities in acute care settings. The work environment is error-prone, especially during complex or high-risk activities, because interruptions and multitasking behaviors create conditions affecting working memory and attention resources. Nurses’ cognitive processes during medication administration are complex and require a high degree of critical thinking and vigilance to prevent patient harm.

Medication administration is one of the most frequently interrupted nursing activities, and strategies to limit interruptions are recommended to improve patient safety.

Studies describing the frequency and characteristics of interruptions during medication administration show that nurses have little protected time to focus on medication administration because of short, frequent interruptions. The most common source of interruptions is interactions with other nursing staff seeking information or assistance with patient care. The frequency of interruptions by other care providers varied significantly across studies. Although they were not the most frequent source of interruptions, phone calls were identified by nurses as one of the most disruptive sources of interruptions and one of the most likely sources of interruptions to be associated with medication errors. System failures such as missing medications and access to equipment and supplies were also identified as sources of interruptions that are potentially avoidable. Other avoidable interruptions cited in the literature are the tendency of nurses to interrupt each other with conversations unrelated to medication administration while preparing medications and to respond immediately to requests from others when interrupted. These findings support the idea that interruptions are an accepted part of nursing practice and suggest the

Patient harm, and strategies to reduce interruptions and manage them appropriately are needed. On the basis of the current evidence, the Institute of Medicine recommends that organizations adopt strategies to reduce interruptions during medication administration as part of a comprehensive medication safety program.

The quality improvement project described here evaluates the impact of adopting evidence-based strategies to limit interruptions during medication administration in 2 progressive cardiac care units (PCCUs) at Advocate Christ Medical Center, a Magnet-designated tertiary care center in the Midwest. A third PCCU served as a comparison unit and, therefore, did not adopt the interruption-limiting strategies. A secondary aim of the project was to evaluate how limiting interruptions affected medication errors in this setting.

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need for culture change to limit avoidable interruptions, especially during complex or high-risk activities such as medication administration.

Development and testing of strategies to limit interruptions during the medication administration process are primarily based on research from the aviation industry. In 1981, the Federal Aviation Authority mandated use of standard operating procedures to create a sterile cockpit situation aimed at reducing unsafe working conditions and preventing errors during high-risk activities such as aircraft takeoff and landing. Essential aspects of the sterile cockpit concept include eliminating interruptions, prohibiting communication unrelated to critical tasks, and maximizing teamwork and coordination during high-risk activities.21,22 The majority of published clinical initiatives to limit interruptions during medication administration are nurse-led quality improvement projects involving implementation of a set of strategies to limit interruptions (Table 1). The goal of these initiatives is to provide nurses with time to remain focused and undisturbed while preparing and administering medications. Direct observations of nurses preparing and administering medications during peak, scheduled administration times were used to study interruptions in these quality improvement projects. Results of these projects demonstrate that implementation of a set of strategies is effective in limiting interruptions and may improve patient safety by decreasing medication errors.

To date, 1 study3 examining the direct relationship between work interruptions and hospital medication administration errors has been published. Results of this landmark study demonstrated that the frequency of interruptions during medication administration increased the risk of both the number and severity of medication errors. Table 2 provides a detailed analysis of the literature regarding cognitive work of nurses and the complexity of the work environment, interruptions during medication administration, strategies used to limit interruptions during medication administration, and the contribution of interruptions to medication errors.

**Introduction to the Progressive Cardiac Care Quality Improvement Project**

The PCCU quality improvement project was developed and implemented on the basis of the work of Nguyen and colleagues.25 In the quality improvement project presented here, the project team implemented a set of evidence-based strategies to limit interruptions during scheduled, peak medication administration times in the progressive cardiac care setting. The project team embedded the interruption strategies into practice guidelines to promote communication, coordination of care, and teamwork during medication administration. The guidelines are referred to as the “NUPASS guidelines,” on the basis of the project’s name: Nurses Uninterrupted Passing Medications Safely (Table 3).

The project’s conceptual framework is based on the medical center’s Evidence-Based Practice (EBP) Model (Figure 1). The EBP model was adopted and modified on the basis of the Iowa model.30 Using the EBP model as a guide, the project team initiated a pilot practice change based on the current evidence supporting use of strategies to limit interruptions during medication administration. The pilot practice change was designed to answer 2 questions: (1) Does implementation of the NUPASS guidelines decrease interruptions during medication administration? and (2) Do medication errors decrease following implementation of NUPASS guidelines? The pilot practice change was conducted on 2 of the 3 PCCUs; PCCU1 and PCCU2 were the intervention units that implemented the NUPASS guidelines, and PCCU3 served as a comparison unit.

Patients cared for in the high-acuity PCCUs typically included patients who required invasive diagnostic and interventional cardiovascular procedures, cardiovascular surgery, and arrhythmia management. Common medical diagnoses included acute coronary syndrome, heart
## Table 2 Detailed review of the literature

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<thead>
<tr>
<th>Reference</th>
<th>Sample/setting</th>
<th>Design/procedures</th>
<th>Purpose</th>
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<tbody>
<tr>
<td><strong>A. Cognitive work of nurses and complex work environment</strong></td>
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<tr>
<td>Potter et al., 2005</td>
<td>Convenience sample of 7 nurses with acute care experience and clinical background Large, tertiary medical center in the Midwest</td>
<td>Mixed method ethnographic observational study combining quantitative human factor engineering techniques with summative nurse interviews Nurses were observed for a total of 48 h</td>
<td>Analyze nurses’ cognitive work and how environmental factors create disruptions that pose risk for medical errors</td>
</tr>
<tr>
<td>Eisenhower et al., 2007</td>
<td>Convenience sample of 40 nurses working in intermediate medical-surgical intensive care unit (M/S ICU) and ante/postpartum unit Large, tertiary teaching hospital in the Northeast</td>
<td>Descriptive study with semistructured interviews</td>
<td>Describe nurses’ thinking during medication administration before and after implementation of bar-code medication scanning (point-of-care technology)</td>
</tr>
<tr>
<td>Kalisch and Aebersold, 2010</td>
<td>Convenience sample of 36 nurses from 5 M/S units, 1 ICU, and 1 progressive care unit Seven patient care units in 2 Midwestern hospitals including an academic medical center and a community-based teaching hospital</td>
<td>Observational study A previously validated instrument referred to as the “Communication Observation Tool” was used by 4 trained staff nurses to collect data For the purpose of this study, both procedural failures and medication administration errors were counted as errors</td>
<td>Evaluate the type and extent of work interruptions, multitasking, and errors</td>
</tr>
<tr>
<td>Cornell and Riordan, 2011</td>
<td>Convenience sample of 19 nurses from 2 hospitals including 8 nurses on an M/S unit at a suburban, acute care hospital and 11 nurses on a pediatric oncology unit at a pediatric research hospital in the United States</td>
<td>Observational study limited to nursing activities outside of the patient’s room during 85.2 h of observation</td>
<td>Assess the complexity of nurse workflow and review its cognitive implications</td>
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<td><strong>B. Interruptions during medication administration</strong></td>
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<tr>
<td>Kreckler et al., 2008</td>
<td>Convenience sample of nurses working on a 37-bed surgical unit at a teaching hospital in the United Kingdom</td>
<td>Observational study Thirty-eight medication passes were observed in 5 weeks</td>
<td>Determine the time required by nurses to deal with interruptions and the nature of nurses’ work interruptions (WIs) during medication administration</td>
</tr>
<tr>
<td>Biron et al., 2009</td>
<td>Convenience sample of 18 nurses working on a medical unit at a tertiary care teaching hospital in Quebec</td>
<td>Observational study Descriptive data included source and duration of interruptions, nursing tasks and location during interruptions and strategies used by nurses to manage interruptions</td>
<td>Document characteristics of nurses’ WIs during medication administration</td>
</tr>
<tr>
<td>Palese et al., 2009</td>
<td>A convenience sample of nurses working on 7 surgical units across multiple, similar type hospitals in Northern Italy</td>
<td>Mixed-method study combining observation of nurses during medication administration followed by nurse interviews during a 3-month period</td>
<td>Examine the frequency and perceived risk of WIs during medication administration</td>
</tr>
<tr>
<td>Biron et al., 2009</td>
<td>Articles from 1980 to 2008 were analyzed</td>
<td>Systematic review Fourteen of 23 studies selected for analysis reported observation times and interruption frequencies and therefore, underwent further analysis</td>
<td>Review the evidence on nurses’ interruption rates, characteristics of WIs, and contribution of WIs to medication administration errors</td>
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Findings/conclusions

Nurses averaged 9 cognitive shifts per hour or a shift in attention focus once every 6-7 min. The human factor engineer found 5.9 interruptions per hour and the nurse researcher found an average of 3.4 interruptions per hour. Twenty-two percent of interruptions occurred in the medication room during medication preparation, and no attempt was made by nurses to control sources of the interruptions.

Nurses’ constant vigilance to provide the appropriate medication was a common theme found in the content analysis. Nurses’ thinking was categorized into 10 descriptive categories; the only change in thinking after implementing bar-code scanning was the descriptive category related to checking medications.

Key aspects of critical thinking identified included assessment of the patient before and after administration of medications, interpretation and verification of relevant laboratory data, application of knowledge to specific patient situations, anticipatory problem solving related to the patient’s expected clinical trajectory and consultation with health care team members to prevent medication errors and adverse drug events.

The mean interruption rate observed at the 2 hospitals was 10 interruptions per hour resulting in a break in task more than 1/3 of the time. Interruptions occurred every 6 minutes for hospital 1 and every 4.5 min for hospital 2; nurses were interrupted during medication administration 57% and 38% of the time in hospital 1 and hospital 2, respectively. Nurses engaged in multitasking an average of 30% and 40% of the time in hospital 1 and hospital 2, respectively. Significantly more interruptions ($P < .001$), multitasking ($P < .001$), and breaks in task ($P < .001$) occurred in ICUs than in the M/S units. No more errors were found when nurses were interrupted or multitasking vs when nurses were not interrupted or multitasking.

More than 2000 tasks were recorded on each unit during 35.7 h of observation on the M/S unit and 49.5 h of observation on the pediatric oncology unit. The duration of tasks was short with a mean of 62.4 (SD, 127.7) s and 49.5 (SD, 81.6) s on the M/S unit and pediatric oncology unit, respectively. The reason for switching tasks (self-directed or external) was not discernible. Nurses frequently changed locations when switching tasks.

Medication passes were interrupted a mean of 11% of the time. Two-thirds of the medication passes were interrupted with a mean of 2.61 interruptions per medication pass. The most frequent sources of interruptions in descending order were (1) interruptions by the nurse administering medication (self-initiated), (2) interruptions by physicians, and (3) interruptions by other staff and patients.

Phone calls were not the most frequent source of interruption; however, they were found to be significant because of their longer duration.

WIs averaged 6.3 per hour (5.2 per hour during medication preparation and 6.8 per hour during medication administration). WIs were of short duration with a mean of 1 min 32 sec (SD, 2 min). The most frequent WIs during medication preparation were by nurse colleagues followed by system failures due to missing medication and equipment. Nurses preparing medications were interrupted by other nurses for personal matters 36% of the time and to exchange verbal reports 22% of the time.

The most frequent WIs during medication administration were self-initiated and by patients during direct patient care activities. Nurses handled WIs immediately more than 98% of the time; the proportion of WIs handled immediately was similar during both medication preparation and administration (98.8% and 97.6%, respectively).

A mean of 1 interruption per 3.2 drugs administered occurred during medication administration. When there was an increased number of drugs per medication pass for a single patient, the number of interruptions increased significantly ($P = .05$). Nurses intervened immediately when interrupted 96% of the time. Nurses perceived interruptions related to management of phone calls to be the highest risk for error during medication administration.

Pooled data from 14 studies found WIs occurred at a rate of 6.7 interruptions per hour. The majority of interruptions were self-initiated by nurses administering medications during face-to-face interactions, occurred most frequently during direct patient care, and were of short duration ranging from 45 sec to 1.2 min. Only 1 nonexperimental study documented the contribution of interruptions to medication errors with evidence of a significant association ($P = .01$).

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Table 2  Continued

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<tr>
<td>Pape,²² 2003</td>
<td>Convenience sample of M/S unit nurses were observed during a single medication pass for assigned patients in a 520-bed acute care hospital in Texas</td>
<td>Quasi-experimental 3-group study design including a comparison group and 2 intervention groups; A validated instrument referred to as the Medication Administration Distraction Observation Sheet (MADOS) was used to count distractions</td>
<td>Test the effectiveness of 2 interventions (“focused” protocol and “medsafe” protocol) to reduce distractions during medication administration in comparison to usual practice; Determine which distractors are more predictive of nurses being distracted during medication administration</td>
</tr>
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<td>Nguyen et al,²⁵ 2009</td>
<td>Forty-five nurses working on a 25-bed M/S unit at an academic teaching hospital in Northern California; The project was conducted in partnership with a larger quality improvement (QI) initiative sponsored by the Integrated Nurse Leadership Program aimed at improving patient safety and involved 7 hospitals in the San Francisco Bay²⁸</td>
<td>A longitudinal observational QI project; One hundred medication passes were observed before the intervention and at 6 months and 1 year after the intervention</td>
<td>Evaluate whether a safety initiative referred to as the “Med Pass Time Out” was effective and sustainable in reducing medication administration errors</td>
</tr>
<tr>
<td>Anthony et al,²⁷ 2010</td>
<td>Convenience sample of medical ICU and surgical ICU nurses working in a tertiary academic medical center in Cleveland, Ohio</td>
<td>Observational pilot project; A “no interruption zone” (NIZ) was created by placing red tape around all medication preparation areas to signify that nurses were not to be disturbed while preparing medications; The number of interruptions before and 4 weeks after the NIZ was implemented were measured; Nurses observed were blinded to the purpose of the study</td>
<td>Evaluate the effect of a NIZ on the number of interruptions during medication preparation</td>
</tr>
<tr>
<td>Freeman et al,¹⁷ 2013</td>
<td>Convenience sample of 99 nurses in a cardiac and thoracic surgical step-down unit at a large, academic medical center in the Midwest</td>
<td>Observational QI project; A modified version of the MADOS instrument was used to count the number and type of interruptions</td>
<td>Determine whether implementation of a set of interventions would reduce distractions during medication administration; A secondary project goal was to reduce medication errors; Interventions implemented were previously described in the literature, including wearing a lighted lanyard during medication administration, triage of phone calls, creating an NIZ in the medication preparation area, signage, and staff and patient/family education</td>
</tr>
<tr>
<td>Williams et al,²⁶ 2014</td>
<td>Convenience sample of nurses working in a surgical progressive care unit (52 before intervention and 48 after intervention); Academic medical center in the southeastern United States</td>
<td>Observational study; Distractions and interruptions were measured using the MADOS instrument before and 2 months after implementation of 5 evidence-based safety strategies including nursing staff education, use of a medication safety vest, NIZ in medication preparation areas, signage on the unit and patient rooms, and a resource tool for scripting responses to interruptions</td>
<td>To evaluate the effectiveness of implementing 5 evidence-based safety strategies to reduce distractions and interruptions during medication preparation</td>
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Significant differences in the mean number of distractions were found between the comparison group and both intervention groups \((P<.001)\) as well as between the 2 intervention groups (“focused” protocol \([P=.01]\) and “medsafe” protocol \([P<.001]\) )

The significant difference between the 2 intervention groups was attributed to use of a visible symbol that the nurse wore during medication administration (a red vest with the lettering “Medsafe Nurse, Do Not Disturb”)

Conversation accounted for the majority (93%) of the variance in distractions, followed by interruptions by personnel (90%) and loud noises

Uninterrupted time increased from 81% to 99% of the time at 6 months and 1 year after implementation of the “Med Pass Time Out”

Medication errors decreased from 2% to 1% at 6 months and improvement was sustained at 1 year

No statistical analysis

The number of interruptions decreased by 40.9% (from 31.8% to 18.8%) after implementation of the NIZ \((P=.03)\).

The proportion of interruptions initiated by nurses preparing medications (self-initiated interruptions) decreased from 25% to 0% following implementation of the NIZ

Mean number of interruptions decreased from 3.29 to 1.18 during medication administration

Medication errors decreased by 28 events when compared with the same time period the year before

Patients, nurses, and patients’ family members represented the top 3 sources of interruptions before implementing interventions to reduce interruptions; 1 month after implementation of the interventions, no interruptions were made by family members

No statistical analysis

Four types of distractions and interruptions decreased significantly after implementation of the safety strategies including those initiated by (1) physicians, nurse practitioners, and physician assistants \((P=.001)\), (2) phone calls and pages \((P<.001)\), (3) other personnel \((P<.001)\), and (4) conversations unrelated to medication administration \((P=.002)\)

Nurse were not found to be compliant with wearing the safety vest or using the resource tool when responding verbally to interruptions but were compliant with use of signage and the NIZ when preparing medications
Table 2  Continued

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<tr>
<td>Westbrook et al.,3 2010</td>
<td>Convenience sample of 98 nurses from 6 units at 2 major teaching hospitals in Sydney, Australia</td>
<td>Observational study A total of 505 hours of observation was conducted during an 18-month period</td>
<td>Examine the direct relationship between WIs and hospital medication administration errors</td>
</tr>
<tr>
<td>Hopkinson and Jennings,29 2013</td>
<td>A total of 31 articles published between 2001 and 2011 were selected for analysis, including 12 that specifically examined nurse WIs during medication administration. Studies were conducted in 7 countries, including 14 studies conducted in US acute care facilities</td>
<td>Systematic review Most studies used a nonexperimental design and involved direct observation methods for data collection</td>
<td>Examine empirical evidence from studies of nurse WIs in the acute care setting</td>
</tr>
<tr>
<td>Raban and Westbrook,21 2014</td>
<td>Ten studies meeting inclusion criteria and published up to September 2012 were analyzed Eight of the 10 studies were published in North America All studies used direct observation for data collection, but studies were not limited to the acute care setting</td>
<td>Systematic review Studies included for analysis were observational studies that reported quantitative data on interruptions or medication administration errors with a pre- and postintervention design or use of a comparison group Studies included were not limited to the acute care setting</td>
<td>Assess evidence of the effectiveness of interventions aimed at reducing interruptions during medication administration on interruption and medication administration error rates</td>
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Table 3  Nurses Uninterrupted Passing Medications Safely (NUPASS) guidelines

Before administering medications
1. Nurses update the charge nurse (CN) before administering medications if there are changes in patients’ status that affect scheduled procedures or transport needs; otherwise, nurses simply place a colored magnet next to their name on the assignment board (board in clear view at the front desk) to indicate that they are administering medications.
2. Nurses dock their phones just outside the medication room before entering to prepare medications. Docked phones are programmed to forward all calls to the front desk.
3. Nurses don a yellow safety sash before leaving the medication room to administer medications.

After administering medications
1. Once medication administration is complete, nurses return their yellow safety sash to the medication room, pick up their docked phone, remove the colored magnet from the assignment board, and check at the front desk for any new messages recorded on a communication log.

General practice progressive cardiac care unit (PCCU) guidelines
1. Nurses perform hourly rounds on odd hours (corresponds with peak, scheduled medication times). Patient care assistants (PCAs) perform hourly rounds on even hours.
2. Phone and face-to-face requests by family for patient information are screened for a password in accordance with the medical centers’ policy for compliance with the Health Insurance Portability and Accountability Act (HIPAA) before contacting the assigned nurse.
3. Nursing staff use key phrases to respond to nonemergent requests or inquiries: “For the safety of our patients,” we do not interrupt the nurse while administering medications. Is there something I can help you with?
4. Unit secretaries refer requests/inquiries to the CN only in situations where they cannot triage or manage the communication themselves.
5. Prespecified peak, scheduled medication administration times for “no interruption” except emergencies: 5 AM-7 AM, 8 AM-10 AM, and 8 PM-10 PM. Emergencies include imminent patient safety concerns, patients’ request for pain medication, emergency response to cardiac arrhythmia alert, need to communicate information only assigned nurse has specific knowledge of in a critical event, rapid response, or cardiopulmonary arrest of assigned patient.
6. Signage on closed medication room door reminds staff that medication room is a “quiet zone.”
7. “No interruption zone” (NIZ) outlined on floor in the medication room next to the medication storage/delivery system.
8. “Daily Patient Care Activity Flowsheet”: Day-shift CN receives a brief report on each patient from the assigned nursing staff, including scheduled procedures and patient transport needs for the next 24 hours before 8 AM daily during “huddle-up.” This information is logged by the day-shift CN on a structured daily flow sheet and is updated by the evening and night CNs on the basis of the corresponding shift reports by nursing staff to assist with coordination of patient care activities.
9. “Communication log”: used to document nonurgent messages while nurses are administering medications.
10. Patient/family education tool: written patient/family education provided on admission to help explain the pilot practice change.
failure, and uncontrolled atrial fibrillation. Patient care was delivered by nursing staff including registered nurses and certified nursing assistants referred to as patient care associates (PCAs). The nurse to patient ratio was 1 to 4 on the day and evening shifts and 1 to 5 on the night shift. The number of beds on each unit was from 36 to 46, and the daily patient census was from 34 to 39. Technology used to support the medication administration process at the time of the pilot practice change included a centralized medication storage system, computer physician order entry, and electronic medication administration record. Bar-code scanning of medications was not available at the time of the pilot practice change. Geographic differences in the layout of the PCCUs included the number of medication rooms and the number of semiprivate versus private patient rooms. The project team for the pilot practice change consisted of 5 bedside nurses from the PCCUs, an advanced practice nurse, and a nurse researcher.

**Methods**

**Data Collection**

The pilot practice change was conducted for 18 months. The baseline percentages of interruptions and medication errors were measured in July 2009, and these measures were repeated after implementation of the NUPASS guidelines in December 2010 (Figure 2). A convenience sample of nurses from each PCCU was randomly observed during peak, scheduled medication administration times. Nurses were aware of being observed during data collection. Data collectors used the following script to explain why they were conducting observations during medication administration:

> We are conducting a quality improvement project to identify opportunities to improve patient safety during medication administration. All data [are] being collected anonymously and [do] not include the identity of the nurses being observed during medication administration.

Observations were conducted during prespecified times (5 AM - 7 AM, 8 AM - 10 AM, and 8 PM - 10 PM). The number of observations conducted for each prespecified time was based on the mean number of medications scheduled during these peak administration times. The project team staff nurses collected all data and observed medication passes on PCCUs other than their own. Two standardized data collection tools referred to as the Medication Administration Accuracy Observation

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**Findings/conclusions**

Each interruption was associated with a 12.1% increase in procedural failures and a 12.7% increase in medication errors. The frequency of interruptions during medication administration increased the risk of both the number and severity of medication errors. The estimated risk of a major error, defined as an error most likely to cause harm, permanent damage or death, doubled from 2.3% with no interruption to 4.7% with 4 or more interruptions during administration of scheduled medications to a single patient.

The evidence for reducing medication errors by limiting interruptions remains at the level of descriptive research because the majority of projects were nurse-led QI projects. Interpretation of results was limited because of the different methods used for unit sampling, measuring, and defining interruptions.

Five studies had statistically significant changes in the number of interruptions before and after implementation of a set of interventions; interruptions decreased in 4 studies and increased in 1 study. The 3 studies that measured changes in medication error rates showed reductions, but all 3 studies implemented multiple interventions besides those aimed at reducing interruptions. Weak evidence of the effectiveness of interventions intended to reduce interruptions and medication error rates exists primarily owing to the small number of studies, and the lack of robust study design, appropriate statistical analyses, and small sample size.
Code Sheet and the Medication Administration Accuracy Review Worksheet developed by the California Nursing Outcomes Coalition (CALNOC) were modified and adapted for use with written permission of CALNOC (March 26, 2009). Before implementation of the pilot practice change, an interrater reliability study involving 30 observations (10 per unit) was conducted to establish agreement among trained data collectors and resulted in 96% agreement. Operational definitions used for the purposes of data collection during the pilot practice project are listed in Table 4.

During observations, the data collectors were blinded to the electronic medication orders to prevent confirmation bias. The Medication Administration Accuracy
Observation Code Sheet is a flowsheet used to record each medication administered during the observation period and to tally each interruption observed during the medication pass. Data collectors used the Medication Administration Accuracy Observation Code Sheet to record each medication administered, including the medication name, dose, route, and the time the medication was administered to the patient. Data collectors were trained to record the reason for all interruptions observed by using a free-text, narrative approach. The project team planned to review the reasons for interruptions after completion of the project and based on post-hoc analysis, develop a scheme for categorizing the sources of interruptions.

The Medication Administration Accuracy Record Review Worksheet is a flowsheet used to identify medication errors retrospectively by comparing medications administered during the observation period with scheduled medication orders on the electronic medication administration record for the same time period.
Following the observed medication passes, data collectors used the Medication Administration Accuracy Record Review Worksheet to reconcile the electronic medication orders with the medications actually administered to the patients to identify medication errors. The number and type of medication errors identified were recorded on the data collection tool, including wrong drug, dose, form, route, and technique and omission of drug dose errors.

Communication Strategies

Once baseline data collection was complete on all 3 units, the project team trained the PCCU1 and PCCU2 nursing staff how to implement the NUPASS guidelines. Staff members were trained to use communication scripts to respond to nonemergent requests when nurses were passing medications. The communication script simply stated, “For the safety of our patients, the nurses are not interrupted while passing medications. Is there something I can help you with?” Use of the phrase “for the safety of our patients” was essential to avoid misconceptions that the nurse was just “too busy” to speak to them. The unit secretary managed most communication with visitors and requests for clerical assistance from physicians and other health care providers while the charge nurse was responsible for addressing patient care issues with physicians and other care providers. The nursing staff was provided with operational definitions of emergencies as part of the NUPASS guidelines; however, because no guidelines address all situations, the members of the nursing staff were coached to consider if a safety concern existed before deciding whether or not to interrupt a nurse during a medication pass.

The nurses and PCAs coordinated patient care activities by alternating hourly patient care rounds to ensure that the timing of nursing rounds corresponded to the peak times for administering scheduled medications. Purposeful, hourly rounding has been demonstrated to decrease patients’ use of call lights and was a best practice established on the PCCUs before the pilot project change. However, as part of the pilot practice change, nurses wore a yellow safety sash during scheduled, peak medication administration times as a visible sign that they were passing medications and were not to be disturbed. Before beginning the medication pass, nurses also placed a colored magnet next to their name on the assignment board to alert other care providers that they were in the process of passing medications. Because the PCCU assignment boards were in clear view from the centralized nursing stations, this tactic provided another visible sign to alert others of the medication pass. Once nurses were done administering medications, they removed their yellow safety sash, picked up their docked phone, removed the magnet from the assignment board, and checked with the charge nurse for any logged messages or updates.

Educational Strategies

Unit staff, physicians, and other care providers hospital-wide were educated on the pilot practice change, including the purpose of the project and instructions for communicating and coordinating care during scheduled, peak medication administration times. Care providers from numerous departments (pharmacy, rehabilitation, nutrition, cardiodiagnostics, emergency, and transportation service) were educated in 6 months. Education strategies included staff newsletters tailored to specific departments, poster presentations, unit-based in-service training programs, and presentations at scheduled staff and physician meetings. Upon admission to PCCU1 and PCCU2, a patient-specific newsletter (Table 5) was used to educate patients and their families about the pilot project change.

Results

During the pilot practice change, 130 medication passes were observed on the 3 PCCUs, including 64 medication passes before and 66 medication passes after guideline implementation. During the 130 medication passes, nurses were observed administering 631 medications: 316 medications before and 315 after guideline implementation. The mean number of medications administered per patient was 4.10, and the mean duration of medication passes was 11.69 minutes. Neither the mean number of medication doses nor the duration of medication passes differed significantly between units before or after guideline implementation.

Interruptions

To answer the first question, the percentage of interruptions decreased significantly in 1 of the 3 PCCUs after...
implementation of the NUPASS guidelines. Interruptions decreased from 23% to 4% \( (P < .001) \) in PCCU1 after implementation of the NUPASS guidelines. In comparison, the percentage of interruptions did not change significantly in PCCU2, and although the change was not statistically significant, the percentage increased in PCCU3 after guideline implementation (Table 6). Based on post-hoc analysis, interruptions were categorized in 2 different ways: (1) source of the interruption and (2) avoidable versus unavoidable interruptions.

Four main sources of interruptions were identified: (1) patient-related, (2) phone calls, (3) verbal (face-to-face interaction), and (4) unavailability of resources (Figure 3). Most of the decrease in interruptions after guideline implementation was due to a 48% reduction in phone calls. The second largest source of interruptions both before and after implementation of the NUPASS guidelines was the unavailability of resources. Of these, 85% were because the nurse had to stop and get water or a cup for the patient before administering medications. In comparison, missing equipment and other supplies accounted for only 15% of the interruptions in this category. The majority of phone calls and verbal (face-to-face) interruptions were related to patient care activities including requests from patients, unit personnel, and other care providers. Interruptions by physicians during the pilot practice change accounted for only 7% of the total interruptions. Patient-related sources of interruptions

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**Table 5** Patient medication safety newsletter

**You may hear today:**

“For the safety of our patients, we do not interrupt the nurses while they are administering medications. Is there something I can assist you with?”

A team of nurses is conducting a project to improve patient safety. The purpose of the project is to increase patient safety by limiting interruptions during medication administration.

**Why is this project important?** Numerous studies suggest that interruptions during medication administration contribute to medication errors.

**How are interruptions limited when the nurses are administering medications?** Nurses will not take phone calls or respond to inquiries from others including nursing staff, therapists, physicians, patients, and families when they are administering medications EXCEPT for emergencies during these times:

- **8 to 10 AM**
- **8 to 10 PM**
- **5 to 7 AM**

**How will I know when the nurse is administering medications?**

Nurses will wear a yellow safety sash to signify that they are administering medications and are not to be interrupted. Limiting interruptions allows the nurses to keep their attention focused on medication administration and the needs of the each patient who is receiving medications.

**What if I need to communicate with my nurse?**

- The phone numbers of your nurse and patient care assistant (“PCA”) are posted on your communication board. You can call them directly to avoid waiting for your call light to be answered.
- When your nurse is administering medications, his/her calls will be automatically forwarded to the front desk for further assistance.
- The nurse and the PCA take turns rounding at your bedside hourly to offer assistance so that your needs are met promptly.
- If you need help to the bathroom, with bathing, or need something to drink or eat, you can call your PCA.

**Who can I talk to if I have more questions about the project?** Your nurse will be able to answer most questions. Please also feel free to direct any questions or comments to the Manager or Advanced Practice Nurse during their daily rounds. This project is a team effort, and we need your help and support to make it a success!

Thank you from the project team!

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**Table 6** Interruptions before and after Nurses Uninterrupted Passing Medications Safely (NUPASS) guidelines were implemented

<table>
<thead>
<tr>
<th>Progressive cardiac care unit (PCCU)</th>
<th>Before NUPASS</th>
<th>After NUPASS</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCCU1 (intervention unit)</td>
<td>22/95 (23%)</td>
<td>5/113 (4%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PCCU2 (intervention unit)</td>
<td>25/118 (21%)</td>
<td>22/99 (22%)</td>
<td>.46</td>
</tr>
<tr>
<td>PCCU3 (comparison unit)</td>
<td>10/103 (10%)</td>
<td>15/103 (15%)</td>
<td>.24</td>
</tr>
</tbody>
</table>
did not differ before or after the implementation of the NUPASS guidelines.

Avoidable interruptions decreased from 18 to 3 (83%) in PCCU1 and from 19 to 9 (53%) in PCCU2 while avoidable interruptions in PCCU3 increased from 7 to 12 (71%) after implementation of the NUPASS guidelines (Figure 4). Although PCCU2 did not show a statistically significant decrease in the total percentage of interruptions following implementation of the NUPASS guidelines, the unit was successful in decreasing avoidable interruptions by more than half. Unavoidable interruptions decreased from 4 to 2 (50%) in PCCU1, increased from 6 to 14 (133%) in PCCU2 and increased from 1 to 2 (100%) in PCCU3 after implementation of the NUPASS guidelines.

Medication Errors

To answer the second question, the percentage of medication errors decreased in all 3 PCCUs after implementation of the NUPASS guidelines (Table 7). A statistically significant decrease in the percentage of medication errors was found in 1 of the 2 intervention units and in the comparison unit. The percentage of medication errors in PCCU1 decreased from 11% to 3% after the guidelines were implemented ($P = .02$). Although the percentage of medication errors in the second intervention unit (PCCU2) decreased from 2% to 1%, the number of observations conducted was not powered to demonstrate a statistically significant change between such low percentages of medication errors. An unanticipated finding was a significant decrease in the percentage of medication errors ($P = .01$) in the comparison unit (PCCU3).

Discussion

Interruptions

Consistent with the findings of numerous published studies, nurses observed during the pilot practice change were frequently interrupted during medication administration. In addition, results of the pilot practice change support earlier reports that the majority of interruptions during medication administration are avoidable and may lead to adverse consequences for patients. The greatest impact of implementing the NUPASS guidelines was the significant decrease in avoidable interruptions, particularly those related to phone
calls. Successfully decreasing interruptions related to phone calls was highly dependent on teamwork and highlights the important role of support staff in prioritizing and managing phone calls during peak scheduled medication administration times.

An important paradigm shift for PCCU nurses was to assume accountability for interruptions, including avoiding social chatter in the medication room and delegating or deferring tasks when appropriate to maintain a concentrated focus on medication administration. The pilot project team identified differences in unit culture, workflow demands throughout the 24-hour period, visibility of leadership, and informal leadership support on each shift as factors that may have influenced nursing staff buy-in and adherence to the NUPASS guidelines. Adherence to the guidelines by physicians, other care providers, and patients was greatly enhanced by education and the use of key messages. The most important message for gaining cooperation and support from physicians was that the practice change was to help “manage” rather than limit communication among care providers.

The responses of patients and their families were overwhelmingly positive when the pilot practice change was introduced, and they often shared how impressed they were that the staff took the patients’ safety so seriously. However, the fact that the number of patient-related interruptions remained the same before and after implementation of the NUPASS guidelines suggests the need to reinforce patient education about the pilot project change throughout the hospital stay such as signage in the patients’ rooms and verbal reminders. Although no clinically significant difference was found in unavoidable interruptions before and after implementation of the NUPASS guidelines in PCCU1 or PCCU3, a large increase in unavoidable interruptions occurred in PCCU2 after guideline implementation; that increase was attributed to orientation and training of newly hired nurses during this period.

Medication Errors

It is not clear why the percentage of medication errors in PCCU2 was lower than in the other 2 units at baseline. The only observable difference between units was that PCCU2 has 2 centralized medication rooms compared with only 1 such room on the other 2 PCCUs. In addition, the finding that the percentage of medication errors decreased significantly after guideline implementation in the comparison unit (PCCU3), independent of the percentage of interruptions, highlights that numerous factors besides interruptions affect patient safety outcomes.

Sustainability of the Pilot Practice Change

The Institute of Medicine recommends that nurses be observed periodically to measure actual medication errors rather than relying completely on voluntary reporting of medication errors. Observation methods to measure medication errors are useful for overcoming pitfalls of traditional event reporting, including underreporting of errors. However, direct observation to measure interruptions and medication errors is time- and resource-intensive because it requires trained data collectors and coordination of data collecting activities. A novel quality improvement approach used at Stanford Health Care for ongoing measurement of interruptions and medication errors shared by Elisa E. Nguyen (e-mail communication, May 22, 2015) is to observe nurses administering medications as part of regularly scheduled hospital prevalence studies. Regardless of the method used for collecting interruption and medication error data, ongoing monitoring for quality improvement and regular, timely feedback to nursing staff regarding measured outcomes is essential to promote a culture of safety and sustain results in high-reliability organizations.

After the official project was completed, the NUPASS project team was not able to continue the quality improvement monitoring activities to evaluate the sustainability of the outcomes associated with the pilot practice change because of time constraints, nursing staff turnover, and lack of funding. Lack of a sustainability plan for this project resulted in a drift back to former practice and is consistent with the findings of Freeman and colleagues, who evaluated the use of a similar set of strategies to limit interruptions in a single progressive care unit. However, in July 2014, a modified version of the pilot practice change was implemented in all patient care units as a best practice with the leadership support of the medical center’s chief nurse executive. A major change in the guidelines is that the yellow safety sash has been replaced by a hand-held...
Bar-code scanner as a visible sign that the nurse is administering medications and is not to be disturbed.

Limitations of the Pilot Practice Change

Although approximately one-third of the PCCU nurses participated in the project, use of a convenience sample of nurses limits the representativeness of the sample. Second, observations were limited to 3 specialty units at a single site, preventing generalization of the findings to other patient populations and health care settings. Third, because the nurses were aware that they were being observed, they may have followed administration safety practices more consistently, leading to fewer medication errors (Hawthorne effect). Finally, the comparison unit (PCCU3) was restructured after the baseline data were collected for the pilot practice change. The restructuring involved cohorting cardiovascular surgical patients at a lower nurse to patient ratio; both of these factors limit the use of PCCU3 as a comparison unit.

Last, for the purposes of this project, the definition of medication errors was limited to administering medications as ordered by the physician. However, progressive care nurses continuously make clinical judgments about the appropriateness of carrying out medication orders. These judgments are based on the patient’s clinical status, relevant laboratory data, and contraindications related to risks of complications associated with diagnostic and interventional procedures. The critical thinking and decision-making processes involved in making these judgments represent important monitoring and surveillance activities nurses use to keep patients safe regardless of the prescribed medication order.

Conclusions

Results of the NUPASS pilot practice change demonstrate that using evidence-based strategies to limit interruptions during medication administration in the progressive cardiac care setting decreases avoidable interruptions and promotes patient safety. Recognizing medication administration as a high-risk activity is critical to transforming the culture and engaging nursing staff to promote the kind of teamwork necessary to limit avoidable interruptions during medication administration. In this pilot practice change, we evaluated the impact of limiting interruptions during medication administration during scheduled, peak administration times. The impact of limiting interruptions on medication errors during unscheduled administration of medications including as-needed medications and initiation and titration of high-risk intravenous infusions (eg, antiarrhythmic and inotropic agents) administered in the progressive care setting warrants further study.

Although no “magic bullet” is available to prevent medication administration errors, the outcomes of this project support the use of evidence-based strategies to limit interruptions during medication administration as part of a comprehensive medication safety program. Bedside nurses have little control over the physical layout of the patient care unit, the nurse to patient ratio, or access to technological advances to prevent medication errors; however, they can successfully affect the work environment to promote patient safety with little or no cost to the organization by adopting evidence-based strategies to limit work interruptions during high-risk activities such as medication administration. CCN

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Financial Disclosures

None reported.

Letter

Now that you’ve read the article, create or contribute to an online discussion about this topic using eLetters. Just visit www.ccnonline.org and select the article you want to comment on. In the full-text or PDF view of the article, click “Responses” in the middle column and then “Submit a response.”

Dotmore


References


Preparing Drugs for Infusion Via Syringe Pump: A Key Step to Ensure Homogeneous Concentration

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Yann Dehu, MS
Fabrice Girault, RN
Bruno Figadère, PhD
Karine Leblanc, MS
Nicolas Briole, MD
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**OBJECTIVE** Preparation of drug solutions used with electronic syringe infusion pumps plays a crucial role in the delivery of an accurate drug concentration. Is there a correlation between drug concentrations during syringe pump infusion and preparation protocols?

**METHOD** Norepinephrine, insulin, and sufentanil were prepared in 3 different ways: (1) the drug was taken from the vial, then the solvent was added followed by an air bubble, and mixing was performed by turning the syringe top-to-bottom in a 180° shaking movement 5 consecutive times; (2) the drug was taken from the vial, then the solvent was added and not mixed; and (3) the solvent was taken from a stock solution, then the drug was added and not mixed. Concentrations of drugs were determined at different times during administration by reverse-phase high-performance liquid chromatography with ultraviolet detection. All analyses were performed in triplicate and were based on measurement of peak areas.

**RESULTS** With no shaking of the syringe, the concentration of the injected drugs varies widely. In any case, mixing of the syringe contents by turning the syringe in a top-to-bottom 180° shaking movement 5 times with an air bubble would ensure administration of the drug at a constant concentration.

**CONCLUSIONS** Without mixing, the concentrations of all drug solutions varied widely when administered via an electronic syringe infusion pump. Mixing syringe contents should be made part of the compulsory curriculum for administering medications at all levels of medical education. (Critical Care Nurse. 2016;36[4]:36-45)

The use of electronic syringe infusion pumps to administer therapeutic agents is common practice in hospitals, particularly among patients who require slow injection treatments. For these patients and their practitioners, it is crucial that the administration of drugs (especially for those having a small therapeutic index) via the syringe pump be consistent, predictable, and reliable. It has been documented that when, for instance, catecholamine blood concentration varies even for a short time, there is a strong adverse effect on patients. Thus, it stands to reason that the use of syringe infusion...
pumps for any such time-lapsed drug administration must be reliably stable and accurate throughout the procedure. In current practice, it is nurses who are responsible for preparing and administering drugs via syringe pumps, but the steps between the prescription and administration of the drug involve many participants, not only nurses. This multiplicity of actors and actions increases the risk of error. Thus, researchers in several studies have reported large differences between the expected concentrations of the drug and the concentrations delivered. Material factors that have been identified as potential causes of drug-concentration discrepancies with syringe pumps include nonstandardized use of equipment such as tubes, valves, injectors, and syringes. Documented human causes of inconsistent drug concentrations include drug mislabeling and improper manipulation of syringes. Errors often found include confusion between 2 products and poor transcription of the prescription, all exacerbated by stress and fatigue. Calculation errors and dilutions are also cited as contributing factors in failure rates.

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be diluted with 5% glucose (28 mL) so as to reach a concentration of 0.25 mg/mL.

Insulin must be continuously administered at a constant rate to patients hospitalized for critical glycemic disorders, which could eventually lead to death if untreated. Insulin (0.5 mL of 1000 IU/10 mL) is diluted with 49.5 mL saline (0.9% sodium chloride solution) so as to obtain a 1 IU/mL solution.

Sufentanil is a synthetic opioid used to potentiate anesthetics during childbirth with epidural analgesia. A study has shown that variations of sufentanil concentration during the delivery process may significantly influence the quality of analgesia. Thus we decided to use ropivacaine (37.5 mL of 0.2% aqueous solution) diluted with saline (0.9% sodium chloride solution, 7.5 mL) and sufentanil (25 μg, 5 mL) so as to obtain 0.5 μg/mL of sufentanil.

### Preparation of Drug Solutions

All solutions were prepared by nurses under the standard conditions used in hospitals. One nurse prepared the solution and another controlled the process by double-checking the work of the first nurse to ensure that the drug concentration was correct. The preparation did not include any complex calculations of doses. Stock solutions, syringes, and drugs were purchased from regular sources and used in the usual way (Table 1).

The material used consisted of Agilia brand electronic syringe infusion pumps (Fresenius SE and Co). This equipment was used in accordance with the factory-directed protocol.

The syringes and needles used were as follows:
- 50-mL syringe (B Braun Medical Inc)
- 1.1 × 40 mm needle (Beckton Dickson BD Microlance).

### Method of Mixing

We chose a mixing method after visual tests had been done with some physiological saline solutions, with the drug being replaced by a coloring agent (methyl alcohol blue). We varied several factors such as the number of reversals of the syringe, the movement of the syringe, and the presence or absence of an air bubble during the agitation. Better results were obtained with the following method: addition of a 5-mL air bubble in the syringe and 5 successive reversals of 180°.

Preparation 1: the drug was taken from the vial, then the solvent was added followed by an air bubble, and mixing was performed by turning the syringe top-to-bottom in a 180° shaking movement 5 consecutive times.

Preparation 2: the drug was taken from the vial, then the solvent was added and not mixed.

Preparation 3: the solvent was taken from a stock solution, then the drug was added and not mixed.

A 0.5-mL syringe was used to draw up the insulin for the preparations so that the precise dose required could be collected. In all cases, air was purged after the sample was prepared.

### Sample Collection

For both norepinephrine and insulin, the same procedure was used to test all 3 preparations. The flow rate of the syringe pump was set to 8 mL/h, and aliquots were collected as follows:
- For norepinephrine, at time zero and then every hour for 4 hours until the syringe was empty.
- For insulin, at time zero and then every 70 min until the syringe was empty.
- Every experimental sequence was repeated 5 times.

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**Table 1** Products used for the study and presentation

<table>
<thead>
<tr>
<th>Generic name</th>
<th>Commercial name</th>
<th>Laboratory</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norepinephrine</td>
<td>Noradrenaline</td>
<td>Mylan</td>
<td>2 mg/mL</td>
</tr>
<tr>
<td>Insulin</td>
<td>Umuline</td>
<td>Lilly</td>
<td>100 IU/mL</td>
</tr>
<tr>
<td>Ropivacaine</td>
<td>Ropivacaine KABI</td>
<td>Fresenius</td>
<td>2 mg/mL</td>
</tr>
<tr>
<td>Sufentanil</td>
<td>Sufentanil</td>
<td>Renaudin</td>
<td>5 μg/mL</td>
</tr>
<tr>
<td>Sodium chloride solution</td>
<td>Chlorure de sodium 0.9%</td>
<td>Macopharma</td>
<td>9 mg/mL</td>
</tr>
<tr>
<td>Glucose solution</td>
<td>Glucose 5%</td>
<td>Macopharma</td>
<td>50 mg/mL</td>
</tr>
</tbody>
</table>
For the sufentanil/ropivacaine mixture only, preparations 1 and 2 were compared by the following method. Boluses of 3 minutes were collected at a flow rate of 100 mL/h every 10 minutes. Thus, 9 boluses were collected. Four aliquots were taken from each bolus every minute (0, 1, 2, and 3) and analyzed 6 times by means of high-performance liquid chromatography (HPLC).

**HPLC Analyses**

Concentrations of drugs were determined by reverse-phase HPLC with ultraviolet detection. Calibration was set for a range of known concentrations of drugs (0-0.8 mg/mL for norepinephrine, 0-2 IU for insulin, and 0-1 μg/mL for sufentanil). Linearity and reproducibility were ascertained for each drug. All analyses were performed in triplicate, based on the measure of peaks area.

For norepinephrine, a diphenyl Pursuit column (4.6 x 150 mm, 5 μm, Varian) was used with a Waters HPLC (600E quaternary pump, automatic sampler 717 and PDA 2996 ultraviolet detector). The mobile phase was H₂O + 0.05% trifluoroacetic acid/methanol (95:5) at 1 mL/min flow rate. Peak analysis (retention time = 207 min) was performed at 278 nm.

For insulin, a C18 Sunfire column (4.6 x 150 mm, 5 μm, Waters) was used with Agilent HPLC (1200 Infinity, ultraviolet detector). The mobile phase was H₂O + 0.1% trifluoroacetic acid/methanol (40:60) at 1 mL/min flow rate. Peak analysis (retention time = 4.2 min) was performed at 270 nm.

For sufentanil, a C18 Sunfire column (4.6 x 150 mm, 5 μm, Waters) was used with Agilent HPLC (1200 Infinity, ultraviolet detector). The mobile phase was H₂O + 0.1% trifluoroacetic acid/acetonitrile (69:31) at 1 mL/min flow rate. Peak analysis (retention time = 8.2 min) was performed at 230 nm.

**Statistical Methods**

Statistical analyses were performed by using R version 3.0.3 (R Foundation for Statistical Computing). For each drug studied, the intrasyringe variability in concentration is expressed by the relative standard deviation, and the mean concentration measurements at each time are compared with one another by the Friedman test. For each preparation method, concentration variability is represented by the overall standard deviation of the measured concentrations. Preparation methods are compared with one another by an overall test of variances comparison (Levene test, based on a nonparametric approach), then by pairwise comparisons, adjusting the P values with the Holm method. The level of significance (type I error) retained is 5%. Numerical results are presented in Tables 2 through 4.

**Results**

**Norepinephrine**

Results are summarized in Figure 1 and Table 2. Best results were obtained for preparation 1, all concentrations are close to the expected concentration (0.25 mg/mL) along the time of administration when the syringes are mixed, with less than 0.3% variation in concentration. For preparations 2 and 3, without shaking, norepinephrine concentrations are different either at the beginning or at the end of administration. Indeed, for preparation 2, 21% of variation of concentration was observed for a single syringe, and for preparation 3, the variation was as high as 33% for 1 syringe.

**Insulin**

Insulin concentrations were measured for the 3 preparations and results are reported in Table 3 and Figure 2. Best results were obtained for preparation 1 (with shaking); those concentrations are close to the expected value (1 IU/mL) at any time of the experiment with less than 1% variation. In preparation 2, where solvent was added to the drug, some variations were observed, especially at the beginning of the administration. However, for preparation 3, where insulin was added after the solvent and without shaking, a variation in the concentration of insulin was observed, up to 57% for the same syringe.

**Sufentanil**

For sufentanil, shaking was crucial for the concentration (Table 4 and Figures 3 and 4). However, in all cases, the first measure (first minute of the first bolus) always showed a lower value than expected (0.5 μg/mL). Furthermore, we observed a slight difference between the 5 syringes that could be due to an experimenter factor (2 persons performed these experiments), and for 1 syringe, an error occurred (the volume of sufentanil was probably lower than expected). In the experiments run without shaking, sufentanil concentration reached the expected value only after the fourth or fifth bolus and finished above the expected concentration by 10% to 30%.

As long as the solution is well mixed, it does not matter whether drug or solvent is introduced first.
Discussion

Our results show that the drug solutions had to be shaken before being infused with the syringe pump in order to obtain a constant drug concentration during the infusion. Indeed, the starting point of this study was to evaluate the effect of mixing and stirring on homogenization of drug solutions used with electronic syringe infusion pumps.

After having reviewed the literature on various errors in drug administration, we set out to develop a practice to minimize such errors. We set up an experimental study to evaluate the impact of different preparation methods on drug concentration. The results indicated that shaking the drug solutions before infusion is crucial for achieving consistent drug concentrations.

### Table 2: Norepinephrine/glucose 5%

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Concentration, mean (SD), mg/mL</th>
<th>Minimum-maximum</th>
<th>95% CI</th>
<th>Relative SD, %</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norepinephrine then glucose 5% with shaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-1</td>
<td>0.2517 (0.0007)</td>
<td>0.2501-0.2530</td>
<td>0.2514-0.2521</td>
<td>0.26</td>
<td>.86</td>
</tr>
<tr>
<td>1-2</td>
<td>0.2486 (0.0005)</td>
<td>0.2479-0.2492</td>
<td>0.2483-0.2488</td>
<td>0.18</td>
<td>.15</td>
</tr>
<tr>
<td>1-3</td>
<td>0.2516 (0.0006)</td>
<td>0.2508-0.2528</td>
<td>0.2512-0.2520</td>
<td>0.25</td>
<td>.03</td>
</tr>
<tr>
<td>1-4</td>
<td>0.2469 (0.0007)</td>
<td>0.2460-0.2479</td>
<td>0.2465-0.2473</td>
<td>0.28</td>
<td>.03</td>
</tr>
<tr>
<td>1-5</td>
<td>0.2506 (0.0003)</td>
<td>0.2503-0.2514</td>
<td>0.2505-0.2508</td>
<td>0.13</td>
<td>.31</td>
</tr>
<tr>
<td>Norepinephrine then glucose 5% without shaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-1</td>
<td>0.2581 (0.0319)</td>
<td>0.2363-0.3191</td>
<td>0.2398-0.2764</td>
<td>12.35</td>
<td>.02</td>
</tr>
<tr>
<td>2-2</td>
<td>0.2627 (0.0394)</td>
<td>0.2360-0.3221</td>
<td>0.2432-0.2822</td>
<td>12.94</td>
<td>.02</td>
</tr>
<tr>
<td>2-3</td>
<td>0.2706 (0.0569)</td>
<td>0.2329-0.3793</td>
<td>0.2380-0.3032</td>
<td>21.04</td>
<td>.02</td>
</tr>
<tr>
<td>2-4</td>
<td>0.2507 (0.0167)</td>
<td>0.2369-0.2827</td>
<td>0.2412-0.2603</td>
<td>6.65</td>
<td>.02</td>
</tr>
<tr>
<td>2-5</td>
<td>0.2537 (0.0086)</td>
<td>0.2442-0.2697</td>
<td>0.2488-0.2587</td>
<td>3.40</td>
<td>.02</td>
</tr>
<tr>
<td>Glucose 5% then norepinephrine without shaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-1</td>
<td>0.2533 (0.0113)</td>
<td>0.2367-0.2708</td>
<td>0.2468-0.2598</td>
<td>4.46</td>
<td>.02</td>
</tr>
<tr>
<td>3-2</td>
<td>0.2581 (0.0650)</td>
<td>0.1889-0.3637</td>
<td>0.2208-0.2953</td>
<td>25.17</td>
<td>.02</td>
</tr>
<tr>
<td>3-3</td>
<td>0.2636 (0.0567)</td>
<td>0.2003-0.3642</td>
<td>0.2311-0.2961</td>
<td>21.51</td>
<td>.02</td>
</tr>
<tr>
<td>3-4</td>
<td>0.2535 (0.0304)</td>
<td>0.2029-0.2893</td>
<td>0.2360-0.2709</td>
<td>12.01</td>
<td>.02</td>
</tr>
<tr>
<td>3-5</td>
<td>0.2405 (0.0787)</td>
<td>0.1274-0.3633</td>
<td>0.1953-0.2856</td>
<td>32.74</td>
<td>.02</td>
</tr>
</tbody>
</table>

### Table 3: Insulin/saline

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Concentration, mean (SD), mg/mL</th>
<th>Minimum-maximum</th>
<th>95% CI</th>
<th>Relative SD, %</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin then saline with shaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-1</td>
<td>1.0257 (0.0053)</td>
<td>1.013-1.030</td>
<td>1.0226-1.0287</td>
<td>0.52</td>
<td>.02</td>
</tr>
<tr>
<td>1-2</td>
<td>1.0287 (0.0064)</td>
<td>1.016-1.036</td>
<td>1.0250-1.0324</td>
<td>0.63</td>
<td>.02</td>
</tr>
<tr>
<td>1-3</td>
<td>1.0446 (0.0096)</td>
<td>1.030-1.056</td>
<td>1.0391-1.0501</td>
<td>0.92</td>
<td>.02</td>
</tr>
<tr>
<td>1-4</td>
<td>1.0364 (0.0060)</td>
<td>1.027-1.044</td>
<td>1.0330-1.0399</td>
<td>0.58</td>
<td>.02</td>
</tr>
<tr>
<td>1-5</td>
<td>1.0214 (0.0090)</td>
<td>1.007-1.030</td>
<td>1.0163-1.0266</td>
<td>0.88</td>
<td>.02</td>
</tr>
<tr>
<td>1-6</td>
<td>1.0192 (0.0096)</td>
<td>1.004-1.032</td>
<td>1.0138-1.0247</td>
<td>0.94</td>
<td>.02</td>
</tr>
<tr>
<td>Insulin then saline without shaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-1</td>
<td>1.0150 (0.0225)</td>
<td>0.9999-1.0960</td>
<td>1.0015-1.0385</td>
<td>2.32</td>
<td>.03</td>
</tr>
<tr>
<td>2-2</td>
<td>1.0498 (0.0346)</td>
<td>1.0130-1.1130</td>
<td>1.0300-1.0696</td>
<td>3.29</td>
<td>.02</td>
</tr>
<tr>
<td>2-3</td>
<td>1.0365 (0.0230)</td>
<td>0.9980-1.0690</td>
<td>1.0233-1.0496</td>
<td>3.47</td>
<td>.02</td>
</tr>
<tr>
<td>2-4</td>
<td>1.0374 (0.0065)</td>
<td>1.0220-1.0450</td>
<td>1.0326-1.0423</td>
<td>2.21</td>
<td>.03</td>
</tr>
<tr>
<td>2-5</td>
<td>0.9968 (0.0336)</td>
<td>0.9338-1.0290</td>
<td>0.9776-1.0161</td>
<td>0.82</td>
<td>.02</td>
</tr>
<tr>
<td>2-6</td>
<td>0.9999 (0.0169)</td>
<td>0.9672-1.0170</td>
<td>0.9902-1.0096</td>
<td>1.69</td>
<td>.02</td>
</tr>
<tr>
<td>Saline then insulin without shaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-1</td>
<td>1.2367 (0.7078)</td>
<td>0.8327-2.5990</td>
<td>0.8310-1.6425</td>
<td>57.23</td>
<td>.02</td>
</tr>
<tr>
<td>3-2</td>
<td>1.1324 (0.2253)</td>
<td>1.0000-1.5720</td>
<td>1.0033-1.2615</td>
<td>19.89</td>
<td>.02</td>
</tr>
<tr>
<td>3-3</td>
<td>1.0725 (0.0483)</td>
<td>1.0250-1.1620</td>
<td>1.0448-1.1002</td>
<td>4.50</td>
<td>.02</td>
</tr>
<tr>
<td>3-4</td>
<td>1.1023 (0.3314)</td>
<td>0.7521-1.6500</td>
<td>0.9123-1.2923</td>
<td>30.07</td>
<td>.02</td>
</tr>
<tr>
<td>3-5</td>
<td>1.0424 (0.0140)</td>
<td>1.0270-1.0670</td>
<td>1.0343-1.0504</td>
<td>1.34</td>
<td>.02</td>
</tr>
<tr>
<td>3-6</td>
<td>1.0083 (0.0397)</td>
<td>0.9460-1.0510</td>
<td>0.9855-1.0311</td>
<td>3.94</td>
<td>.02</td>
</tr>
</tbody>
</table>
protocol wherein pairs of nurses were invited for the study, and within each pair, the following controls were set in place: simple and straightforward calculations were used; the protocol applied by one nurse was checked by the other; and solvents were chosen in light of preestablished recommendations.

In the case of norepinephrine administration, the observed variation (21% for preparation 2 and 33% for preparation 3) is much higher than acceptable variations in drug concentrations (10%). These concentration discrepancies could have a highly negative effect on patients who are in unstable hemodynamic

Table 4 Ropivacaine/sufentanil

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Concentration, mean (SD), mg/mL</th>
<th>Minimum-maximum</th>
<th>95% CI</th>
<th>Relative SD, %</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ropivacaine, then saline, then sufentanil, with shaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-1</td>
<td>0.5415 (0.0090)</td>
<td>0.4933-0.5537</td>
<td>0.5398-0.5432</td>
<td>1.66</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>1-2</td>
<td>0.5097 (0.0142)</td>
<td>0.4260-0.5223</td>
<td>0.5069-0.5124</td>
<td>2.79</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>1-3</td>
<td>0.5289 (0.0099)</td>
<td>0.4712-0.5385</td>
<td>0.5270-0.5308</td>
<td>1.86</td>
<td>.001</td>
</tr>
<tr>
<td>1-4</td>
<td>0.5562 (0.0133)</td>
<td>0.4799-0.5686</td>
<td>0.5536-0.5588</td>
<td>2.38</td>
<td>.01</td>
</tr>
<tr>
<td>1-5</td>
<td>0.5048 (0.0122)</td>
<td>0.4401-0.5445</td>
<td>0.5025-0.5071</td>
<td>2.41</td>
<td>.002</td>
</tr>
<tr>
<td>1-6</td>
<td>0.4491 (0.0111)</td>
<td>0.3852-0.4631</td>
<td>0.4470-0.4513</td>
<td>2.48</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Ropivacaine, then saline, then sufentanil, without shaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-1</td>
<td>0.4734 (0.0712)</td>
<td>0.2762-0.5497</td>
<td>0.4597-0.4870</td>
<td>15.04</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2-2</td>
<td>0.5243 (0.1912)</td>
<td>0.2079-0.6560</td>
<td>0.4877-0.5609</td>
<td>36.46</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2-3</td>
<td>0.5658 (0.0196)</td>
<td>0.4836-0.6004</td>
<td>0.5620-0.5696</td>
<td>3.47</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2-4</td>
<td>0.5298 (0.0597)</td>
<td>0.3482-0.5763</td>
<td>0.5184-0.5413</td>
<td>11.26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2-5</td>
<td>0.5375 (0.0150)</td>
<td>0.4628-0.5613</td>
<td>0.5347-0.5404</td>
<td>2.78</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>2-6</td>
<td>0.5700 (0.1134)</td>
<td>0.2788-0.6599</td>
<td>0.5482-0.5917</td>
<td>19.90</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Figure 1 Norepinephrine concentration versus time according to the method of preparation.
**Figure 2** Insulin concentration versus time according to the method of preparation.

**Figure 3** Sufentanil concentration versus time according to the method of preparation, with shaking.
condition, requiring inappropriate adjustment of the administered doses.

For insulin administration, the concentration variation (up to 57%) is even more significant during preparation 3. These differences in drug concentration, compared with the expected insulin concentration, could have severe deleterious glycemic effects on treated patients.

For sufentanil, these concentration variations (10% to 30% for the nonshaking preparation) are observed before the third bolus. This factor may explain the loss of analgesic effects observed when ropivacaine/sufentanil mixture is epidurally administered via a syringe pump to women in labor. Failure to reach the analgesic concentration is one of the causes of ineffectiveness of an epidural analgesic.²⁹

It is important to note that all of the drug solutions were shaken with (1) an air bubble and (2) mixing by turning the syringe top-to-bottom in a 180° shaking movement 5 consecutive times. To our knowledge, these 2 measures have never been recommended. This method is reproducible and easy to teach in nursing schools.

The differences observed for the drug concentrations between preparations 2 and 3 may be explained by several factors that have not been studied: viscosity, density, and speed of solvent introduction. However, all things being equal, stirring of the 3 drug solutions allowed us to obtain constant concentrations throughout an infusion via a syringe pump.

Limitations

Several limitations affected our work:

- Syringes whose contents were intended to be mixed were prepared according to the habits of the nurses, thus according to both proposed methods (some nurses added solvent first, some added drug first). The results after mixing were comparable, so we did not differentiate between the initial preparations.
- The intermittent samplings do not correspond to reality, except in the case of sufentanil. Continuous tests could be done for more precise results.
- We used 50-mL syringes, which are typically used in France; nevertheless, some teams may use 20-mL syringes, which could yield different results.
- Our study was limited to 3 drugs, but as the viscosity of other drugs of interest may vary, results with other drugs could be different.
Conclusions
This is an experimental study that calls for clinical studies to confirm the effects of mixing the drug solutions in the syringes on the patients. Proper preparation of drug solutions infused via electronic syringe pumps is crucial for the delivery of an accurate drug concentration, just as improper preparation contributes to multiple types of errors. For drugs with a narrow therapeutic index, control of the drug concentration is often required for the drug to be effective and to avoid complications. In certain cases, commercially available drug solutions would be an ideal target that would eliminate preparation problems (eg, viscosity, solubility) resulting from human error. In any case, mixing of the syringe contents by shaking the solution in a top-to-bottom 180° shaking movement 5 times with an air bubble would be an ideal compromise and would ensure that the drug is administered at a constant concentration. The mixing technique described here is simple, quick, and does not cost anything, so we encourage adoption of this technique for preparing drug solutions for infusion via a syringe pump. We strongly recommend that this practice become part of the compulsory curriculum at all levels of medical education. This study demonstrates that there is more to discover about and correct within our most mundane practices.

Acknowledgment
We particularly thank Eric Pussard, MD, for his methodological assistance.

Financial Disclosures
This study was supported by funding for a nurse research program from the French Ministry of Health.

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dotmore

References
Preparation of drug solutions used with electronic syringe infusion pumps plays a crucial role in the delivery of an accurate drug concentration. Is there a correlation between drug concentrations during syringe pump infusion and preparation protocols?

- Norepinephrine, insulin, and sufentanil were prepared in 3 different ways: (1) the drug was taken from the vial, then the solvent was added followed by an air bubble, and mixing was performed by turning the syringe top-to-bottom in a 180° shaking movement 5 consecutive times; (2) the drug was taken from the vial, then the solvent was added and not mixed; and (3) the solvent was taken from a stock solution, then the drug was added and not mixed.

- Concentrations of drugs were determined at different times during administration by reverse-phase high-performance liquid chromatography with ultraviolet detection. All analyses were performed in triplicate and were based on measurement of peak areas.

- With no shaking of the syringe, the concentration of the injected drugs varies widely. In any case, mixing of the syringe contents by turning the syringe in a top-to-bottom 180° shaking movement 5 times with an air bubble would ensure administration of the drug at a constant concentration.

- Proper preparation of drug solutions infused via electronic syringe pumps is crucial for the delivery of an accurate drug concentration, just as improper preparation contributes to multiple types of errors. For drugs with a narrow therapeutic index, control of the drug concentration is often required for the drug to be effective and to avoid complications.

- In certain cases, commercially available drug solutions would be an ideal target that would eliminate preparation problems (eg, viscosity, solubility) resulting from human error.

- The mixing technique described here is simple, quick, and does not cost anything, so we encourage adoption of this technique for preparing drug solutions for infusion via a syringe pump.

- Without mixing, the concentrations of all drug solutions varied widely when administered via an electronic syringe infusion pump. Mixing syringe contents should be made part of the compulsory curriculum for administering medications at all levels of medical education.

- This study demonstrates that there is more to discover about and correct within even our most mundane practices. CCN
Treating Central Catheter–Associated Bacteremia Due to Methicillin-Resistant \textit{Staphylococcus aureus}: Beyond Vancomycin

Shannon Holt, PharmD, BCPS-AQ ID
Kelly A. Thompson-Brazill, DNP, ACNP-BC, CCRN-CSC
E. Ryan Sparks, PharmD
Juliana Lipetzky, PharmD

Methicillin-resistant \textit{Staphylococcus aureus} is a frequent cause of hospital-associated infections, including central catheter–associated bacteremia. Vancomycin has been the drug of choice for treating this type of bacteremia for decades in patients who have no contraindications to the antibiotic. However, resistance to vancomycin is an emerging problem. Newer antibiotics approved by the Food and Drug Administration have activity against methicillin-resistant \textit{S aureus}. Some of the antibiotics also have activity against strains of \textit{S aureus} that are intermediately susceptible or resistant to vancomycin. This article uses a case study to highlight the clinical signs of vancomycin failure and describes the indications for and appropriate use of alternative antimicrobials such as ceftaroline, daptomycin, linezolid, tigecycline, and telavancin. (\textit{Critical Care Nurse}. 2016;36[4]:46-57)

According to the Centers for Disease Control and Prevention, methicillin-resistant \textit{Staphylococcus aureus} (MRSA) is a leading cause of health care–associated infections. It is responsible for more than 75,000 severe infections and approximately 11,000 deaths each year in the United States.\textsuperscript{1} \textit{S aureus} is both a commensal skin organism and a pathogen. Colonization can lead to infection when a breach occurs in the skin or mucosal defense systems because of trauma or common procedures

\textbf{CE 1.0 hour, Pharma 0.5 hour}

This article has been designated for CE contact hour(s). The evaluation tests your knowledge of the following objectives:
1. Discuss the signs of vancomycin failure in the treatment of methicillin-resistant \textit{Staphylococcus aureus} (MRSA) central catheter–associated bacteremia
2. Describe the indications for use of daptomycin and ceftaroline for treatment of MRSA central catheter–associated bacteremia
3. Verbalize at least 2 nursing interventions that help prevent MRSA central catheter–associated bacteremia

To complete evaluation for CE contact hour(s) for test #C1643, visit www.ccnonline.org and click the “CE Articles” button. No CE test fee for AACN members. This test expires on August 1, 2019.

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such as surgery or placement of a central catheter. Several different risk factors have been reported for MRSA infections (Table 1) in inpatients, including patients with central intravenous catheters. MRSA is a common cause of bacteremia and is the causative organism reported in 7.4% of central catheter–associated bloodstream infections (CLABSIs) in critical care patients. CLABSIs occur in approximately 80,000 critically ill patients annually in the United States. The infections are associated with prolonged stays in the intensive care unit (ICU) and the hospital and with increases in overall health care costs. Prevention of CLASI is necessary to achieve goals for patient safety and maximize hospital reimbursement from the Centers for Medicare and Medicaid Services. Accordingly, the Centers for Disease Control and Prevention collaborated with other organizations to develop guidelines and checklists to help clinicians and health care facilities prevent CLABSIs. This emphasis on preventive measures has contributed to an almost 50% decrease in CLABSIs due to MRSA from 1997 to 2007.

For patients with suspected CLASI, the guidelines of the Infectious Diseases Society of America (IDSA) recommend starting systemic antimicrobial therapy after blood for culturing has been obtained and, if possible, removing the intravascular catheter. Initial empiric therapy should include drugs effective against gram-positive organisms commonly found on the skin, including S aureus. Most patients with suspected CLASI are given vancomycin because of the increased prevalence of MRSA in health care settings, and combination therapy with a drug effective against a broad spectrum of gram-negative organisms should be considered for patients who are critically ill or immunocompromised. Vancomycin remains the first-line option for treatment of documented MRSA bacteremia. However, several antimicrobial agents are effective against nosocomial MRSA infections. Each agent differs in the mechanism of action, indications for use, clinical and laboratory monitoring required, and adverse effects. Unfortunately, data are limited on use of these agents in patients with MRSA bacteremia, including CLASI.

In this article, we present the case study of a patient with CLASI due to MRSA who required alternative antibiotic therapy to eradicate the infection, and we discuss other agents that may be used to treat MRSA CLABSIs. Identifying information has been changed to protect the patient’s privacy and confidentiality.

Vancomycin
Vancomycin has been used to treat penicillin-resistant infections for more than 50 years and is the first-line treatment option for MRSA CLASI (Table 2). Vancomycin is widely available and costs less than newer antibiotics designed to treat MRSA infections. However, determining the best dosage is difficult, tissue penetration is highly variable, routine trough-level monitoring is required, and infusion-related reactions and anaphylaxis can occur. Vancomycin also can be nephrotoxic.

Table 1 Risk factors for hospital-acquired infection with methicillin-resistant Staphylococcus aureus (MRSA)

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotic treatment in the past 90 days</td>
<td></td>
</tr>
<tr>
<td>Hospital stay of 5 or more days within the past 12 months</td>
<td></td>
</tr>
<tr>
<td>Residence in a long-term care facility</td>
<td></td>
</tr>
<tr>
<td>Open skin wound and/or central intravenous catheter, including hemodialysis patients</td>
<td></td>
</tr>
<tr>
<td>Recent major surgery</td>
<td></td>
</tr>
<tr>
<td>Medical condition causing immunosuppression</td>
<td></td>
</tr>
<tr>
<td>Hospital stay at a health care facility with high rates of MRSA infection</td>
<td></td>
</tr>
</tbody>
</table>

Vancomycin has been used to treat penicillin-resistant infections for more than 50 years and is the first-line treatment option for MRSA CLASI. However, determining the best dosage is difficult, tissue penetration is highly variable, routine trough-level monitoring is required, and infusion-related reactions and anaphylaxis can occur. Vancomycin also can be nephrotoxic.
treatment and increased mortality have been documented in patients who require elevated concentrations of vancomycin to inhibit growth of MRSA isolates. Isolates that require elevated levels of the antibiotic encompass those reported as intermediately susceptible or resistant to vancomycin (minimum inhibitory concentrations [MICs] <2 μg/mL) and those for which the vancomycin MIC is 2 μg/mL; the latter isolates are still reported as sensitive under current laboratory standards.6,13,20 As a result, the IDSA vancomycin guidelines13 suggest that an alternative agent should be considered in MRSA infections for which the vancomycin MIC is 2 μg/mL or less, particularly if the patient is not responding to treatment. Alternative agents are also recommended in patients who have persistent bacteremia during therapy with vancomycin regardless of the reported MIC value (vancomycin failures).5 Although vancomycin remains the drug of choice, alternative agents may be used to treat invasive MRSA infections (Table 2).5,13-19 Alternative MRSA therapy is based on the reported MIC values, bactericidal activity, antibiotic penetration at the infection site, and patient comorbid conditions, including reduced renal function.6,21 See Table 3 for antibiotic pharmacology definitions.

**Alternative Treatments for MRSA Infections**

**Daptomycin**

Daptomycin (Cubicin) is a lipopeptide antibacterial agent that has rapid bactericidal activity against aerobic...
## Table 2  Treatment options for bacteremia and central catheter–associated bloodstream infections due to methicillin-resistant *Staphylococcus aureus* (MRSA)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Vancomycin&lt;sup&gt;13&lt;/sup&gt;</th>
<th>Linezolid&lt;sup&gt;14&lt;/sup&gt;</th>
<th>Daptomycin&lt;sup&gt;16&lt;/sup&gt;</th>
<th>Telavancin&lt;sup&gt;16&lt;/sup&gt;</th>
<th>Tigecycline&lt;sup&gt;17&lt;/sup&gt;</th>
<th>Ceftaroline&lt;sup&gt;18&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common dosing</td>
<td>15-20 mg/kg every 8-12 h</td>
<td>600 mg every 12 h</td>
<td>6-10 mg/kg every 24 h</td>
<td>10 mg/kg every 24 h</td>
<td>100 mg x1 then 50 mg every 12 h</td>
<td>600 mg every 12 h</td>
</tr>
<tr>
<td>Route</td>
<td>Intravenous</td>
<td>Intravenous and oral</td>
<td>Intravenous</td>
<td>Intravenous</td>
<td>Intravenous</td>
<td>Intravenous</td>
</tr>
<tr>
<td>Infusion times</td>
<td>Minimum of 60 min</td>
<td>30-120 min</td>
<td>2-min intravenous bolus or 30-min infusion</td>
<td>60 min</td>
<td>30-60 min</td>
<td>60 min</td>
</tr>
<tr>
<td>Renal dose adjustment</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Effect on MRSA</td>
<td>Slowly bactericidal</td>
<td>Bacteriostatic</td>
<td>Bactericidal, concentration dependent</td>
<td>Bactericidal, concentration dependent</td>
<td>Bacteriostatic</td>
<td>Bactericidal, time dependent</td>
</tr>
<tr>
<td>Mechanism of action</td>
<td>Inhibits bacterial cell wall synthesis</td>
<td>Inhibits bacterial protein synthesis</td>
<td>Binds the cell membrane and causes rapid depolarization</td>
<td>2 mechanisms: inhibits cell wall synthesis and disrupts cell membrane function</td>
<td>Inhibits bacterial protein synthesis by blocking the binding of transfer RNA to the bacterial ribosome</td>
<td>Inhibits bacterial cell wall synthesis</td>
</tr>
<tr>
<td>Recommendations per IDSA MRSA 2011 guidelines&lt;sup&gt;6&lt;/sup&gt;</td>
<td>Bacteremia</td>
<td>Persistent bacteremia</td>
<td>Bacteremia Persistent bacteremia</td>
<td>Persistent bacteremia</td>
<td>Not recommended in IDSA MRSA 2011 guidelines because of a study that showed increased risk of death compared with risk with other agents</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Recommendations per IDSA CRBSI 2009 guidelines&lt;sup&gt;9&lt;/sup&gt;</td>
<td>Preferred empiric and MRSA treatment option</td>
<td>Alternative MRSA treatment option</td>
<td>Should not be used empirically</td>
<td>Alternative MRSA treatment option</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Laboratory monitoring</td>
<td>SCr routinely</td>
<td>CBC weekly platelet monitoring</td>
<td>CPK weekly with coagulation tests and falsely increase clotting times</td>
<td>SCr at least every 2-3 days Pregnancy test before start of treatment Can interfere with coagulation tests and falsely increase clotting times</td>
<td>Monitor for increases in INR if patient is receiving warfarin concomitantly</td>
<td>SCr routinely</td>
</tr>
<tr>
<td>Drug cost (AWP) per day for a 75-kg patient&lt;sup&gt;19&lt;/sup&gt;</td>
<td>$15.00</td>
<td>$501.90 intravenous</td>
<td>$425.66</td>
<td>$371.36</td>
<td>$243.20</td>
<td>$303.24</td>
</tr>
</tbody>
</table>

Abbreviations: AWP, average wholesale price; CBC, complete blood cell count; CPK, creatine phosphokinase; CRBSI, catheter-related bloodstream infection; IDSA, Infectious Diseases Society of America; INR, international normalized ratio; SCr, serum creatinine; WBC, white blood cell count.
gram-positive bacteria, including MRSA (Table 2). Daptomycin has been approved by the Food and Drug Administration (FDA) for treatment of MRSA bacteremia, including right-sided endocarditis. In the IDSA guidelines, the antibiotic is recommended as a first-line option for MRSA bacteremia. Daptomycin is a concentration-dependent antibiotic, and higher doses of 8 to 10 mg/kg per day may be considered for more invasive infections.6,15 Clinical success rates are similar for daptomycin and vancomycin (44.4% vs 31.8%; \( P = .28 \)) in patients with MRSA bacteremia and endocarditis.22 In addition, daptomycin may be preferred over vancomycin in MRSA bacteremia caused by isolates with vancomycin MIC values greater than 1 μg/mL because of improved patient outcomes. Murray et al23 conducted a matched retrospective cohort study (n = 170) in patients with MRSA bacteremia with elevated vancomycin MIC values (for 94.1% of the bacterial isolates, the MIC of vancomycin was 2 μg/mL). Compared with the control group, patients in the daptomycin group had significantly lower rates of unsuccessful treatment (20.0% vs 48.2%; \( P < .001 \)), lower 30-day mortality (3.5% vs 12.9%; \( P = .05 \)), and lower rates of persistent bacteremia (18.8% vs 42.4%; \( P = .001 \)). In patients with persistent bacteremia and unsuccessful treatment with vancomycin, high-dose daptomycin (10 mg/kg per day) in combination with another agent to which the MRSA isolate is susceptible is a recommended option per IDSA guidelines.6 However, combination therapy is not routinely used in clinical practice because of the lack of supporting clinical evidence.

Although daptomycin has solid clinical data to support its use in MRSA bacteremia, treatment with this antibiotic has drawbacks. Daptomycin should not be used in patients with suspected pneumonia because the drug is inactivated by pulmonary surfactant. Serious adverse events reported include myopathy and rhabdomyolysis. Serum levels of creatinine phosphokinase should be checked weekly during the treatment to monitor for development of toxic musculoskeletal effects. Concomitant use of other agents that may cause myopathy, including inhibitors of 3-hydroxy-3-methyl-glutaryl-coenzyme A reductase (statins), may increase the risk of increasing the levels of creatinine phosphokinase and should be avoided if possible.15 Data are limited on the coadministration of daptomycin and statins, and results of a recent retrospective observational study24 indicated a slightly higher incidence of elevations in creatinine phosphokinase level when combination therapy was used (6.1% vs 2.9%; \( P = .38 \)). Elevations in phosphokinase level rarely result in discontinuation of therapy. However, discontinuation of therapy should be considered in patients with myopathy and concurrent elevations in the enzyme level (5 times the upper limit of the reference range) or in patients with elevations 10 times or greater than the upper limit of the reference range. Clinicians may also consider stopping administration of statins temporarily while the patient is being treated with daptomycin.15

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bactericidal</td>
<td>Agents that kill bacteria.</td>
</tr>
<tr>
<td>Bacteriostatic</td>
<td>Agents that halt bacterial growth.</td>
</tr>
<tr>
<td>Minimum inhibitory concentration (MIC)</td>
<td>Smallest concentration of antibiotic required to inhibit the growth of bacteria.</td>
</tr>
<tr>
<td>Concentration-dependent killing</td>
<td>Antibiotic activity that depends on the peak blood concentrations of the antibiotic in relation to the MIC for the specific organism, with higher peak concentrations resulting in optimized bacterial killing.</td>
</tr>
<tr>
<td>Time-dependent killing</td>
<td>Antibiotic activity that depends on the maintenance of antibiotic blood concentrations greater than the MIC of the specific organism for the specified part of the dosing interval. The optimal amount of time the concentration remains about the MIC varies depending on the antibiotic.</td>
</tr>
<tr>
<td>Volume of distribution ( (V_d) )</td>
<td>The theoretical volume or space within the body that a drug occupies, resulting in the measured drug concentration in the patient’s serum. Larger volumes of distribution generally indicate that a drug distributes well into various tissues in the body, whereas smaller volumes of distribution indicate that a drug is predominately contained within the intravascular space.</td>
</tr>
</tbody>
</table>

Table 3 Antibiotic pharmacology definitions

\( ^a \) Based on information from Pankey and Sabath.21
Other rare adverse effects include eosinophilic pneumonia, peripheral neuropathy, and anaphylaxis. In addition, daptomycin may falsely prolong prothrombin time and elevate the international normalized ratio.\textsuperscript{15}

**Linezolid**

Linezolid (Zyvox) was approved by the FDA in 2000. This member of the oxazolidinone class has bacteriostatic activity against aerobic gram-positive bacteria and against multidrug-resistant gram-positive organisms, including MRSA and organisms with reduced susceptibility to vancomycin (Table 2).\textsuperscript{14} Although linezolid is recommended for treatment of several different MRSA infections, it is not a first-line empiric or definitive treatment option in MRSA bacteremia, including CLABSIs.\textsuperscript{6} Available data do support use of linezolid as an alternative agent in MRSA bacteremia. The effectiveness of linezolid as definitive treatment for MRSA bacteremia was shown in an observational compassionate use program\textsuperscript{25} as well as a pooled analysis\textsuperscript{26} of data from 5 randomized controlled trials that showed similar clinical cure rates for vancomycin and linezolid (46% vs 56%; odds ratio, 1.47; 95% CI, 0.50-4.31). Additionally, findings of an open-label randomized controlled study\textsuperscript{27} published in 2009 indicated that linezolid and vancomycin treatment of MRSA CLABSIs had similar successful clinical outcomes (79% vs 76%; 95% CI, -21 to 27). However, further analysis of data on patients with suspected CLABSIs whose cultures were negative for microorganisms or positive for gram-negative pathogens, the linezolid group had a higher mortality rate than did the comparative group (21.5% vs 16%). Because of these data, the FDA issued an update for the linezolid package insert to state that linezolid should not be used for treatment of CLABSI.\textsuperscript{14} In the IDSA guidelines,\textsuperscript{6,9} linezolid is recommended solely as an alternative agent for patients with documented or persistent MRSA bacteremia.

Prolonged linezolid therapy may increase the risk for hematological toxic effects (thrombocytopenia, anemia, and neutropenia), peripheral neuropathy, and lactic acidosis.\textsuperscript{14} Complete blood cell counts should be monitored in patients receiving linezolid for longer than 2 weeks to assess for myelosuppression. Linezolid is a monoamine oxidase inhibitor that places patients at risk for serotonin syndrome when they are receiving other serotonergic agents. Concurrent use of linezolid and serotonergic agents should be avoided if possible, and the FDA has specific recommendations for handling this drug interaction when simultaneous administration is necessary.\textsuperscript{14,28}

**Telavancin**

Telavancin (Vibativ) is a bactericidal lipoglycopeptide antibiotic approved by the FDA in 2009. It has 2 mechanisms of action against gram-positive organisms, a characteristic that makes it unique\textsuperscript{16} (Table 2). The IDSA guidelines for treatment of MRSA infections reserve it for salvage therapy in patients with MRSA bacteremia caused by isolates with reduced susceptibility to vancomycin or patients whose treatment with vancomycin was unsuccessful.\textsuperscript{6} In a phase 2 randomized study,\textsuperscript{29} telavancin was compared with standard therapy for the treatment of uncomplicated \textit{S. aureus} bacteremia. Of the 30 patients with uncomplicated MRSA bacteremia, 29 experienced a clinical cure. In this study with a small number of patients, patients treated with telavancin had a higher incidence of adverse events (90%) than did patients who received standard therapy (72%); nephrotoxic effects were the most common.

Telavancin should be used solely as an alternative agent when the anticipated benefits outweigh the risks of exposure to the antibiotic. Adverse events include nephrotoxic effects, taste disturbances, and a prolonged QT interval.\textsuperscript{16} Telavancin is contraindicated in patients with prolonged QT intervals, severe left ventricular hypertrophy, and decompensated heart failure. The manufacturer recommends pregnancy testing before treatment with this antibiotic for women who are non-menopausal and have not had a tubal ligation, hysterectomy, or bilateral oophorectomy because of the risk of fetal harm. Infusions of telavancin should be administered during a period of at least 60 minutes to avoid the risk of reactions, including flushing of the upper part of the body, rash, and pruritus, all of which also can occur with rapid administration of vancomycin. Telavancin does not affect blood coagulation; however, anticoagulation test results are falsely altered, similar to the alterations caused by daptomycin. In order to ensure more accurate results, blood samples for coagulation studies should be obtained just before the next scheduled dose of telavancin to allow the effects on the test results to decrease.\textsuperscript{16}
Tigecycline

Tigecycline (Tygacil), a glycylcycline antibiotic approved by the FDA in 2005, has bacteriostatic activity against MRSA\(^\text{17}\) (Table 2). The current IDSA MRSA guidelines do not include tigecycline because of its black box warning for increased mortality and the availability of other agents active against MRSA.\(^\text{6}\) This black box warning was based on an increased 30-day mortality reported in a meta-analysis with data from phase 3 and 4 trials.\(^\text{30,31}\) The highest mortality risk occurred in patients treated with tigecycline for ventilator-associated pneumonia. In addition to the increased mortality, blood levels of tigecycline are low because of its large volume of distribution\(^\text{32}\) (Table 2). This pharmacokinetic property of the drug along with its bacteriostatic activity has called into question its effectiveness in patients with bacteremia. No studies on its use for primary MRSA bacteremia have been published.

The effectiveness of tigecycline in patients with secondary bacteremia was evaluated in an analysis of pooled data from 8 multicenter trials.\(^\text{33}\) Gardiner et al\(^\text{33}\) reported that tigecycline was effective for patients with bacteremia associated with community-acquired bacterial pneumonia, complicated skin/skin-structure infections, and intra-abdominal infections; however, only 6 patients in the tigecycline group had MRSA bacteremia. Adverse effects include severe nausea and vomiting, severe skin reactions, QT prolongation, pancreatitis, and hepatotoxic effects. Drug interactions with tigecycline are uncommon; however, the antibiotic may alter the clearance of warfarin, resulting in an increased international normalized ratio. The international normalized ratio should be monitored when tigecycline and warfarin are administered concomitantly.\(^\text{17}\) On the basis of the current literature, tigecycline cannot be recommended for treatment of primary MRSA bacteremia, including MRSA CLABSI.

Ceftaroline

Ceftaroline (Teflaro) is a bactericidal cephalosporin\(^\text{18}\) (Table 2). Ceftaroline’s specific affinity for penicillin-binding proteins 2a and 2x makes it effective against *Streptococcus pneumoniae* and *S aureus*, including MRSA.\(^\text{34}\) Ceftaroline is not included in the 2011 IDSA MRSA guidelines because the antibiotic had not been approved by the FDA when the guidelines were published.\(^\text{6}\) Since publication of the guidelines, several retrospective studies and case reports on use of this antibiotic, both as monotherapy and in combination with other agents, for treatment of MRSA bacteremia have been published.\(^\text{35-40}\) Polenakovic and Pleiman\(^\text{39}\) reported clinical success with ceftaroline therapy in 23 of 31 patients (74.2%) with MRSA bacteremia. The sample included 7 patients with intravenous catheter–associated MRSA infections and 10 patients given combination MRSA therapy. The most common reason for use of ceftaroline was elevated MIC values (MIC>1 μg/mL) for vancomycin.

More recently, in a multicenter retrospective case-control study (n = 32),\(^\text{38}\) ceftaroline salvage therapy (started after 5 days of vancomycin therapy) was compared with vancomycin alone in treating MRSA bacteremia caused by organisms for which MIC levels for vancomycin were higher (≥2 μg/mL). Time to eradication of MRSA was significantly shorter (P = .06) with ceftaroline (4 days) than with vancomycin (8 days), and clinical success at the end of treatment was significantly higher (P = .06) for ceftaroline (81%) than for vancomycin (44%).

In another retrospective study, Casapao et al\(^\text{35}\) analyzed ceftaroline use at several sites during a 2.5-year period. Of the 527 patients included in the study, 241 (45.7%) had documented MRSA infections. Bacteremia was reported in 48 patients (28.1%); in 10 of the 48, the infections were associated with use of intravenous catheters. The majority of patients (80.1%) were treated with vancomycin before therapy with ceftaroline was started; the median duration of vancomycin therapy was 3 days. Clinical success was achieved in 79% of the bacteremia subgroup (112 of 141 patients). The success rate was 79% with both the standard dosing and the off-label dosing (600 mg intravenously every 8 hours).

Combination therapy with ceftaroline has also been reported. Sakoulas et al\(^\text{40}\) used ceftaroline plus daptomycin for 26 patients with documented refractory staphylococcal bacteremia. Patients had persistent bacteremia for median of 10 days with previous therapy. Among the 26 patients, 20 had MRSA infections and 14 had endocarditis. After combination therapy was started, the median time to bacteremia clearance was 2 days (range, 1-6 days).

This increasing amount of evidence helps support the notion that ceftaroline may be considered as an...
alternative antibiotic in the treatment of MSRA bacte-
meria and CLABSIs, including instances when patients 
have disease progression on standard therapy.

Adverse events reported with ceftaroline are minimal 
and are similar to those associated with other cephalo-
sporins. Hypersensitivity reactions to penicillins and 
carbapenems should be considered before therapy with 
ceftaroline is started because most likely cross-reactivity 
exists between β-lactam antibiotics. In addition to 
common adverse events associated with treatment with 
β-lactam antibiotics, case reports have described the 
development of eosinophilic pneumonia.

**Nursing Care**

Although appropriate antibiotic therapy is a key element 
in managing CLABSI due to MRSA, instituting evidence-
based infection control measures is required to prevent the 
spread of MRSA and other multidrug-resistant organisms. 
Multiple studies have shown that decreasing the skin’s 
bacterial load with chlorhexidine gluconate (CHG) baths 
decreases rates of infection with MRSA and other patho-
gens. CHG is a topical antiseptic active against a large 
number of both gram-positive and gram-negative microbes. 
Bathing patients with 2% CHG solution is recommended 
by the Centers for Disease Control and Prevention for 
preventing CLABSIs.

In addition to CHG bathing and other methods of 
decolonization, such as administering mupirocin ointment 
intranasally, consistently applying infection prevention 
and control practices can halt the spread of infections due 
to multidrug-resistant organisms. Research has indicated 
that implementing use of bundles for insertion of central 
venous catheters decreases the incidence of 
CLABSI. Bundle elements include performing hand 
hygiene, using CHG for skin cleansing, and instituting 
full-barrier precautions before insertion of the catheter. Having registered nurses assist in insertion of central venous catheters and monitor bundle compliance is an important step in preventing CLABSI. The Joint Commission recommends having nurses complete an insertion checklist that incorporates these bundle elements as a patient safety measure.

Empowering nurses to stop the insertion if breaks in sterile technique occur is critical in minimizing the threat of bacterial migration into the bloodstream. The need for central venous catheters should be reassessed frequently, and any unnecessary devices should be removed to decrease the risk of CLABSI. Once the catheters are placed, nurses should actively survey the site for signs of infection, including erythema, warmth, and purulent drainage. If the site becomes infected, a physician or a midlevel provider should be notified promptly. In these instances, removal of the catheter is recommended by the Centers for Disease Control and Prevention.

For patients with bacteremia or other severe infections 
caused by MRSA or other multidrug-resistant organisms, 
response to treatment must be assessed. Up to 1 week 
may be required after the start of treatment with appropri-
ate antibiotics before blood cultures indicate eradica-
tion of MRSA. If a patient’s clinical status is worsening 
despite antibiotic therapy, the causative organism may 
be resistant to the current medication. The patient’s 
clinical status should be correlated to laboratory values, 
especially the white blood cell count. A decrease in the 
white blood cell count is not always an indication the 
antibiotic is effective.

Drug-induced neutropenia is associated with some 
classes of medications, including anti-infectives. The 
neutropenia usually occurs within 2 to 60 days after 
administration of a drug. Drug-induced neutropenia 
increases the risk for sepsis and may predispose patients 
to hospital-acquired infections. Superinfections can also result from 
antibiotic use. Monitoring is required for the develop-
ment of oral thrush, vaginal yeast infections, and other 
superinfections, as well as *Clostridium difficile*–associated 
diarrhea. Vancomycin, linezolid, and ceftaroline may 
decrease bone marrow production. Monitoring the 
complete blood cell count can help detect neutropenia, 
anemia, and thrombocytopenia before these blood 
abnormalities become clinically relevant.

The bactericidal activity of vancomycin depends on 
the ratio of the area under the curve to the MIC of van-
comycin for the organism in question. Trough levels are 
used as a surrogate marker to ensure a target ratio greater 
than 400. Correct timing is essential in obtaining blood 
samples to determine trough levels. Measurements of 
vamcomycin troughs are most accurate when the medici-
cation has reached its steady state. The blood samples 
should be obtained just before the fourth dose in patients.

Registered nurses can help prevent CLABSI by assisting in insertion of central venous catheters and monitoring bundle compliance.
with normal renal function. If a blood sample is obtained too early, the level will be higher than it would be if the sample were obtained at the correct time. In a retrospective analysis of 2597 blood samples obtained during a 13-month period, Morrison et al found that more than 41.3% of the samples obtained to measure vancomycin troughs were obtained too early. The samples that were obtained early yielded higher trough levels than did samples obtained at the appropriate time. Measurements that inaccurately indicated elevated levels may prompt the provider or clinical pharmacist to inappropriately adjust subsequent vancomycin doses. Subtherapeutic levels can lead to vancomycin-resistant bacteria and potential treatment failures.

Patient Education

Because MRSA CLABSIs typically require a minimum of 14 days of antibiotic therapy after the first blood culture is negative for the microbe, some patients will be discharged before they complete their course of treatment. At the time of discharge, general education for patients taking antibiotics to treat MRSA CLABSIs should focus on reminding the patients to take the drugs as instructed, not skip doses, and not stop the medication until the course of therapy is finished. Discharge education should include information on the potential adverse effects of the antibiotic, including superinfections and Clostridium difficile–associated diarrhea. Patients should be educated on the signs and symptoms to look for and when to notify the prescribing health care provider.

Counseling patients on preventing the spread of MRSA to others is important. Hand hygiene keeps MRSA from spreading. Hand washing is preferable, but alcohol-based gel hand sanitizers are also effective, except for Clostridium difficile–associated diarrhea. Patients should cover all draining wounds to prevent transmission of the bacteria. Because patients usually have some type of long-term venous access, such as a peripherally inserted central catheter, they and their family members should be instructed on proper care of the catheter and use of aseptic technique before, during, and after each administration of antibiotic. Patients should be educated about the signs of infection at the catheter site and be instructed to notify their provider if infection occurs. Patients and caregivers assisting with dressing changes must wear gloves during wound care and must wash their hands immediately after. Family members should be warned to avoid sharing personal or hygiene items with the patient. Nurses should encourage frequent cleaning of surfaces with which the patient infected with MRSA comes into contact with a product labeled as a disinfectant. The agent must stay in contact with the contaminated surface for 10 minutes. Clothing and linen should be laundered frequently. If wound drainage is present, these items should be washed daily. Additionally, patients with active MRSA infections should avoid participating in contact sports and in exercising at public facilities such as gyms until the patients are cleared by their health care provider.

Conclusions

Vancomycin has remained the agent of choice for treating MRSA bacteremia for several decades. Recent research supports use of alternative agents for MRSA bacteremia, but the use of these agents is often reserved for patients who cannot tolerate vancomycin, have persistent bacteremia during treatment with vancomycin, or have MRSA infections for which vancomycin MICs are elevated. Daptomycin has the most data to support its use as an alternative agent in MRSA bacteremia in both the IDSA 2009 CLABSI and 2011 MRSA guidelines. Linezolid should be reserved for salvage therapy. In addition, ceftaroline has increasing retrospective clinical data to support its use as an alternative agent in MRSA bacteremia, including CLABSIs, and in patients in whom standard therapy has been unsuccessful. Recently, 3 new MRSA-active agents have been approved by the FDA: dalbavancin, oritavancin, and tedizolid. All 3 agents have activity against MRSA, but currently no data are available to support their use in MRSA bacteremia or CLABSIs. Unfortunately, resistance to available antibiotics is occurring quicker than new agents are being developed. Antimicrobial stewardship efforts to ensure the optimal prescribing of these available broad-spectrum anti-MRSA antibiotics are needed to help decrease the development of multidrug-resistant organisms. In addition to preventing the development of resistant organisms, evidence-based...
practices such as isolation, proper cleaning of high-touch surfaces, and CHG bathing to decrease bacterial load are essential in preventing the spread of MRSA. CCN

Financial Disclosures
None reported.

do not provide any new references or comment on. In the full-text or PDF view of the article, click "Responses" in the middle column and then "Submit a response."

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References


According to the Centers for Disease Control and Prevention, methicillin-resistant Staphylococcus aureus (MRSA) is a leading cause of health care–associated infections. Colonization can lead to infection when a breach occurs in the skin or mucosal defense systems because of trauma or common procedures such as surgery or placement of a central catheter. MRSA is a common cause of bacteremia and is the causative organism reported in 7.4% of central catheter–associated bloodstream infections (CLABSIs) in critical care patients. Most patients with suspected CLABSI are given vancomycin because of the increased prevalence of MRSA in health care settings, and combination therapy with a drug effective against a broad spectrum of gram-negative organisms should be considered for patients who are critically ill or immunocompromised.

**Vancomycin**

- Treatment of a CLABSI depends on the causative organism, removal of the infected catheter, patient-specific factors, and complications. Vancomycin is the first-line option for treatment of documented MRSA bacteremia.
- Determining the best dosage of vancomycin is difficult, tissue penetration is highly variable, routine trough-level monitoring is required, and infusion-related reactions and anaphylaxis can occur.
- The Infectious Diseases Society of America vancomycin guidelines suggest that an alternative agent should be considered in MRSA infections for which the vancomycin minimum inhibitory concentration is 2 μg/mL or less, particularly if the patient is not responding to treatment.
- Although vancomycin remains the drug of choice, alternative agents may be used to treat invasive MRSA infections, including daptomycin (Cubicin), linezolid (Zyvox), telavancin (Vibativ), tigecycline (Tygacil), and ceftaroline (Teflaro).

**Nursing Care**

- Instituting evidence-based infection control measures is required to prevent the spread of MRSA and other multidrug-resistant organisms. Studies have shown that decreasing the skin’s bacterial load with chlorhexidine gluconate baths decreases rates of infection.
- Implementing use of bundles for insertion of central venous catheters decreases the incidence of CLABSI. Bundle elements include performing hand hygiene, using chlorhexidine gluconate for skin cleansing, and instituting full-barrier precautions before insertion of the catheter.
- Having registered nurses assist in insertion of central venous catheters and monitor bundle compliance is an important step in preventing CLABSI.
- Empowering nurses to stop the insertion if breaks in sterile technique occur is critical in minimizing the threat of bacterial migration into the bloodstream.
- Superinfections can result from antibiotic use. Monitoring is required for the development of oral thrush, vaginal yeast infections, and other superinfections, as well as Clostridium difficile–associated diarrhea.
- Counseling patients on preventing the spread of MRSA to others is important. Hand hygiene keeps MRSA from spreading. Hand washing is preferable, but alcohol-based gel hand sanitizers are also effective, except for Clostridium difficile–associated diarrhea.
- Patients should cover all draining wounds to prevent transmission of the bacteria.
- Patients and their family members should be instructed on proper care of the catheter and use of aseptic technique before, during, and after each administration of antibiotic. Patients should be educated about the signs of infection at the catheter site and be instructed to notify their provider if infection occurs. CCN
Obese patients have complex needs that complicate their care during hospitalization. These patients often have comorbid conditions, including hypertension, heart failure, obstructive sleep apnea, pressure ulcers, and difficulty with mobility. Obese patients may be well served in the progressive care setting because they may require more intensive nursing care than can be delivered in a general care unit. Progressive care nurses have core competencies that enable them to safely and effectively care for obese patients. A plan of care with interdisciplinary collaboration illustrates the integrative care for obese progressive care patients. (Critical Care Nurse. 2016;36[4]:58-63)

A new epidemic has developed in the United States. During the period 2009 through 2010, the prevalence of obesity was 35.5% among adult men and 35.8% among adult women. This prevalence is of great consequence in the hospital because a large preponderance of patients who are admitted are obese. According to estimates, during the years 2004 through 2008, more than 4 million morbidly obese patients were hospitalized in the United States. In intensive care units (ICUs), 1 of 3 patients is obese, and 7% are classified as morbidly obese. Cawley and Meyerhoefer estimated that the national medical care costs of obesity-related illness was $209.7 billion, with 20.6% of US national health expenditures spent treating obesity-related illness. Obesity is associated with a myriad of other diseases, including diabetes, incontinence, hypertension, heart disease, gastroesophageal reflux, sleep apnea, joint disease, pressure ulcers, soft tissue infection, and some malignant neoplasms. Comorbid conditions related to obesity may necessitate more frequent nursing assessments and increased vigilance in monitoring. Obese patients require a high degree of nursing care and time to help manage and prevent complications that may occur because of obesity-related conditions. Progressive care units provide an excellent setting for obese patients who require increased monitoring and may have unstable clinical conditions.
Obesity-Associated Risks and Complications

Obesity includes a multitude of physiological changes that may hinder the capacity of a patient to adapt to the potential stressors of critical illness. Obesity exerts its effects on many organ systems and may alter the expected response to illness, leading to the increased possibility of an unstable clinical condition and a need for increased vigilance in monitoring. Assessments of the cardiac and respiratory system should be a priority in obese patients.

Some researchers have hypothesized that obesity may trigger a chronic state of inflammation that leads to progression of cardiovascular disease. Obesity is related to an increased risk for myocardial infarction, heart failure, and premature atherosclerosis. Because of the large increase in cardiac workload during activity and mobilization in obese patients, heart rate and blood pressure should be assessed frequently. Hypertension is also more prevalent in overweight and obese patients than in patients with normal weight in the same risk categories. Appropriately sized blood pressure cuffs must be available to provide accurate information. Obesity is also an important consideration in the development of pulmonary dysfunction.

Obesity may adversely affect pulmonary physiology and lung function because of its effects on the mechanics of ventilation. Pulmonary conditions associated with obesity include obesity hypoventilation syndrome, obstructive sleep apnea, and respiratory failure. Obesity hypoventilation syndrome is defined as a triad of obesity, daytime hypoventilation, and sleep-disordered breathing in the absence of alternative diagnoses and is accompanied by daytime hypercapnia and hypoxemia. The syndrome is characterized by obesity (BMI ≥ 30) with awake arterial hypercapnia (Paco₂ > 45 mm Hg). Thorough respiratory assessments should be completed with frequent monitoring.

CASE STUDY

YZ, a 56-year-old woman, is 162.6 cm tall, weighs 127 kg, and has a body mass index (BMI) of 48.04 (calculated by dividing weight in kilograms by height in meters squared). YZ was admitted to a general medical unit with community-acquired pneumonia, and intravenous antibiotic therapy was started. She had a history of myocardial infarction, coronary artery disease, hyperlipidemia, hypertension, and depression. She had an ischemic stroke 5 years earlier, which left her with left-sided weakness. She had limited mobility at home, and most days she moved only from bed to wheelchair to commode. Since being hospitalized, she had not ambulated, and she refused to get out of bed because she feared that the hospital recliner could not accommodate her weight, despite reassurances from the nursing staff and physical therapist. Clinical findings on day 3 of hospitalization included body temperature 39.2°C and radiographic indications of worsening pneumonia.

Results of arterial blood gas analysis while she was receiving 4 L of oxygen via nasal cannula were pH 7.26, Pao₂ 44 mm Hg, Paco₂ 70 mm Hg, oxygen saturation 77%, and bicarbonate 18 mEq/L. Despite noninvasive mechanical ventilation, her condition continued to deteriorate, and she required intubation and transfer to the medical ICU. The ICU stay was complicated by a catheter-related urinary tract infection due to a difficult catheterization that required multiple attempts. Weaning from mechanical ventilation was difficult because she had existing obesity hypoventilation. A tracheostomy was placed on hospital day 10. During the ICU stay, mobilization was attempted but was difficult because of her anxiety and deconditioned status. Despite appropriate turning and positioning, a stage II pressure ulcer developed on the right buttock.

YZ has continued treatment with mechanical ventilation and is tolerating short weaning trials of continuous positive airway pressure. She is awaiting transfer to the progressive pulmonary care unit for possible weaning.
oximetry monitoring. Positioning patients supine may increase their signs and symptoms because of the increased intrathoracic pressure they may experience and the reduced respiratory capacity due to the abdominal pressure placed on the diaphragm. Placing patients in the semi-Fowler position helps alleviate pressure and allows increased expansion of the diaphragm. Obstructive sleep apnea is characterized by frequent airway obstruction that results in apnea, numerous arousals from sleep, and oxygen desaturation.\textsuperscript{10} Assessment for daytime sleepiness caused by disturbances of sleep and hypoxemia is critical. Additional clinical manifestations may include heavy snoring and morning headaches. Treatment may include noninvasive mechanical ventilation; a proper-fitting interface is required to ensure that the patient can tolerate this treatment. An association also exists between obesity and dyspnea. The feeling of dyspnea may account for the decreased exercise tolerance and decreased mobility in obese patients. Ease and work of breathing may improve when patients are placed in the semi-Fowler position, which will allow increased lung expansion and reduce abdominal pressure on the diaphragm.

The benefits of progressive mobility are well established. Maintaining an obese patient’s mobility while dealing with issues such as dyspnea and exercise intolerance and adhering to guidelines for safe patient handling poses unique challenges to nurses and other interprofessional team members. Appropriate equipment, lack of staff knowledge, and shortage of adequate numbers of caregivers may all be barriers to mobility.\textsuperscript{11} The consequences of immobility are numerous, including neuromuscular dysfunction, metabolic disturbances, organ system abnormalities, and increased hospital lengths of stay.\textsuperscript{12} In order to improve mobility in obese patients, several best practices have been established. Height and weight should be measured for all patients who are admitted to the hospital to ensure that the correct equipment is available or obtained to enhance early mobility. Waist circumference should also be measured to ensure that the bed will accommodate the abdominal girth of the patient. Safe patient-handling algorithms are widely available in clinical practice and can guide bedside nurses in selecting equipment in collaboration with physical and occupational therapists. Staff knowledge of the location and appropriate use of such equipment is imperative. Staff education should include hands-on training with the equipment, knowledge of the weight capacity of equipment, where to obtain the equipment, and how to notify if equipment malfunctions and should be ongoing as equipment changes. Staff should also be educated on the necessity to maintain patients’ privacy, comfort, and dignity during mobilization and transfers.

Obesity poses distinctive challenges for maintenance of skin integrity. The body mass of obese patients exerts increased pressure on dependent tissue and when coupled with possible immobility may lead to increased risk for pressure ulcers. In addition, obese patients may be unable or find it difficult to reposition themselves or help their caregivers do so, a characteristic that contributes to the development of pressure ulcers. A retrospective cohort study\textsuperscript{13} of 4 groups of ICU patients revealed higher rates of pressure ulcers in both underweight and extremely obese (BMI > 40) patients than in normal weight or obese patients (BMI ≥ 25 or < 40).

Pressure ulcers in obese patients may occur in uncommon areas. Skin assessment should include skin folds under the breasts, beneath the abdomen, in the perineal and gluteal folds, the posterior part of the neck, and the lumbar and midback areas.

Modifications in clinical care, including nutritional support, may affect clinical outcomes in patients with obesity.\textsuperscript{14} Obese persons often have high-calorie malnutrition; their intake of calories is excessive but is also deficient in essential nutrients. A nutritional consultation is indicated if nutrient deficiencies are identified or if nutritional support is needed to maintain skin integrity and promote wound healing. Use of evidence-based clinical practice guidelines is essential to guide nurses in managing obese patients’ complex dietary needs. Education of patients and their families is integral to help with adherence to the nutritional plan and adoption of new eating patterns.

**Role of Progressive Care**

The prevalence of obesity in ICU patients ranges from 9% to 26%, and the prevalence of morbidly obese patients is 1.4% to 7%.\textsuperscript{8} Obese patients who have been
admitted to the ICU or who have the potential for unstable clinical conditions may benefit from being admitted to a progressive care unit before transfer to a general care unit or discharge to home. The multiple effects of obesity on all organ systems and obesity-related complications during hospitalization necessitate heightened monitoring. According to the American Association of Critical-Care Nurses,15 progressive care is “care that is delivered to patients whose needs fall along the less acute end of the continuum.” Progressive care patients are patients whose clinical condition is moderately stable and less complex than that of ICU patients and who require moderate resources and intermittent nursing vigilance or patients who are in stable condition but have a high potential for unstable conditions and require an increased vigilance and intensity of care.15

Progressive care nurses are expected to have certain core competencies to provide safe patient care. These competencies are consistent with the care required by obese hospitalized patients. Obese patients with respiratory compromise may require frequent respiratory assessments, noninvasive mechanical ventilation, mechanical ventilation, and tracheostomy care. Core competencies for progressive care related to respiratory issues include interpretation of arterial blood gas analyses, management of patients requiring noninvasive oxygen delivery systems, assessment of patients treated with mechanical ventilation, and knowledge of long-term mechanical ventilation and weaning.15

Obese patients may also be at greater risk than nonobese patients for cardiovascular compromise, including myocardial infarction, heart failure, and hypertension. Progressive care nurses are expected to be certified in basic and advanced life support; be competent in basic dysrhythmia monitoring, interpretation, and treatment techniques; and have knowledge of hemodynamic monitoring and the equipment required for monitoring.15 A particular area of concern for obese patients is mobility and the complications that may arise, including pressure ulcers, atelectasis, pneumonia, and deconditioning, if mobility is not a primary priority. Barriers to mobility include lack of knowledge of equipment, fear of harming the patient, and inadequate staffing levels to safely mobilize patients. Staffing ratios on progressive care units are often 1 nurse to 3 patients or 1 nurse to 4 patients. These ratios may allow adequate staff and ability to focus on the complexity of mobilizing obese patients.

Obese patients may have a decreased ability to adapt to the stressors of illness and are at higher risk than nonobese patients for unstable clinical conditions. Core competencies of progressive care nurses include the ability to recognize the signs and symptoms of cardiopulmonary emergencies and the ability to initiate interventions and to stabilize a patient’s condition while the patient awaits transfer to critical care.15 The inherent characteristics of hospitalized obese patients and the core competencies of progressive care nurses provide synergy between the patients and the setting in which they are provided care. Progressive care nurses are able to provide the increased monitoring and vigilance necessary for obese patients.

The complexity of care for obese patients is multifaceted, as evidenced by the obesity-associated risks and complications mentioned earlier. Progressive care nurses must be provided with tools and evidence-based protocols to implement safe and effective care for obese patients. Evidence-based protocols and care plans, if readily available at the bedside, can provide a means to organize care. The Table provides a sample plan of care that details each body system and provides specific interventions and resources needed to implement each activity. Coordination of care is important and can be accomplished under the direction of an advanced practice nurse.

**Summary**

The requirements of hospitalized critically ill obese patients present unique challenges to the nurses who provide care for these patients in both critical and progressive care units. The best practices and strategies discussed here may provide the opportunity for nurses to become familiar with obesity-related complications, assessments, interventions, and the specific competencies integral to providing care to obese patients. The care plan and case study illustrate the imperative for interprofessional collaboration and coordination to deliver optimal outcomes to these patients. CCN
<table>
<thead>
<tr>
<th>System</th>
<th>Problem</th>
<th>Intervention</th>
<th>Resources</th>
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<tbody>
<tr>
<td>Cardiac</td>
<td>Cardiac complications including hypertension, dyslipidemia, coronary artery disease, stroke, and deep vein thrombosis</td>
<td>Ensure appropriate monitoring equipment is available, including adequate-size blood pressure cuff to ensure accurate readings During activity and mobilization, heart rate and blood pressure should be closely monitored because of the large increase in cardiac workload If mechanical prophylaxis is ordered, ensure appropriate fit of pneumatic compression devices or compression stockings Encourage early mobilization and ambulation</td>
<td>Cardiology consultation Advanced practice nurse to coordinate mobility efforts and monitoring of patient</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>Artificial airway safety</td>
<td>Coordinate weaning from mechanical ventilation with secretion clearance and pain management Progression toward tracheostomy removal as secretions can be cleared and oxygen needs are met Ensure secure fit of tracheostomy support device—may need adjustment for increased neck circumference</td>
<td>Respiratory care Pulmonologist Nurse practitioner Care manager and social worker for discharge planning</td>
</tr>
<tr>
<td>Obstructive sleep apnea/hypoxia</td>
<td>Noninvasive ventilation or continuous positive airway pressure as needed, especially when patient is recumbent or asleep Ensure proper fit and comfort with interface device Administer oxygen as needed to maintain goal oxygenation with sleep and activity Assess for daytime sleepiness, heavy snoring, and morning headaches</td>
<td>Data from bedside oximetry, overnight oximetry studies, arterial blood gas analysis, and pulmonary function testing</td>
<td></td>
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<tr>
<td>Musculoskeletal</td>
<td>Immobility and deconditioning with critical illness; joint pain with degenerative joint disease and increased body mass index</td>
<td>Use a daily plan for mobility; out of bed to chair, then progression to ambulation as tolerated Secure adequate staff numbers and equipment appropriate for the patient’s needs to ensure safe handling of patient</td>
<td>Physical therapist, occupational therapist, unlicensed assistive personnel coordinated by nurse to ensure safe transfers of patients Equipment appropriate for weight and girth to assist with standing and walking Support of ventilator or oxygen with respiratory therapy if needed</td>
</tr>
<tr>
<td>Nutrition</td>
<td>Potential malnutrition and/or inadequate glycemic control</td>
<td>If patient is receiving tube feedings, use eventual progression to oral intake to meet protein and caloric needs for activity and wound healing if applicable Rely on team effort including nursing and nutrition to teach patient and patient’s family about dietary guidelines Obtain routine weights and routine laboratory assessment of complete metabolic profile to provide feedback on progress</td>
<td>Speech therapy to evaluate swallowing if indicated Nutritionist to assess needs and plan for adequate dietary intake; assist with patient and family teaching related to dietary choices Advanced practice nurse to provide coordination for teaching plan Endocrine team involvement for glycemic control if applicable</td>
</tr>
<tr>
<td>Skin integrity</td>
<td>Pressure ulcers, dermatitis, and possible fungal rash</td>
<td>Assess for pressure, including areas where skin-on-skin contact may cause friction Provide local care of pressure ulcers and use of chair cushion and pressure relief mattress Be vigilant with hygiene for skin folds and avoiding new areas of breakdown Provide adequate-size bariatric commode to encourage continence</td>
<td>Wound ostomy continence nurse for products and coordination of care with nurses and other team members for follow-through on recommendations and evaluation of any changes</td>
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<tr>
<td>Psychological</td>
<td>Depression</td>
<td>Provide focused goals and diversional activities</td>
<td>Psychiatric nurse practitioner or psychology resource for counseling and follow-up Social work for discharge planning</td>
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<tr>
<td></td>
<td>Pain</td>
<td>Ensure medications are timed appropriately to provide comfort with mobility and dressing changes if applicable</td>
<td>Nurse practitioner and staff nurses</td>
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### Table Continued

<table>
<thead>
<tr>
<th>System</th>
<th>Problem</th>
<th>Intervention</th>
<th>Resources</th>
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<tbody>
<tr>
<td>Elimination</td>
<td>Incontinence</td>
<td>Promote continence with bowels and bladder with a toileting plan and use of a bariatric bedside commode when patient is able</td>
<td>Advanced practice nurse and staff nurse to coordinate effort with care team to achieve goals</td>
</tr>
<tr>
<td></td>
<td>Constipation</td>
<td>Ensure adequate fluid intake and medication plan if necessary to prevent straining</td>
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Financial Disclosures
None reported.

**eLetters**
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**dotmore**

**References**
Conventional and Unconventional Lifesaving Therapies in an Adolescent With Amlodipine Ingestion

Karin E. Reuter-Rice, PhD, CPNP-AC, CCRN
Bradley M. Peterson, MD

Amlodipine, a dihydropyridine calcium channel blocker, is commonly prescribed for the treatment of hypertension. Ingestion of an overdose leads to severe hypotension; if the hypotension is not treated, death may be imminent. Conventional and unconventional interventions were used to treat an adolescent who ingested a life-threatening dose of amlodipine. Severe hypotension resistant to conventional treatment with intralipids and hyperinsulinemia-euglycemia therapy led to the use of plasmapheresis and a pneumatic antishock garment as lifesaving measures. Plasmapheresis has been described in only one other case of severe amlodipine overdose, and the use of a pneumatic antishock garment has never been described in the management of a calcium channel blocker overdose. Because short-term use of a pneumatic antishock garment has associated risks, the critical care nurse’s anticipation of side effects and promotion of safe use of the garment were instrumental in the patient’s care and outcome. (Critical Care Nurse. 2016;36[4]:64-69)
Case Report

A 16-year-old girl with a history of multiple suicide attempts came to the emergency department (see Figure). No relevant family medical history was available because the patient was an adopted child. On arrival, she was ambulatory with assistance, had a Glasgow Coma Scale score of 14, and acknowledged taking a handful of amlodipine belonging to a family member. She became progressively obtunded in the emergency department, and the score on the Glasgow Coma Scale decreased to 8. She was intubated and had severe refractory hypotension despite administration of crystalloid fluid boluses and dopamine and norepinephrine infusions.

The patient was transferred to the pediatric intensive care unit (PICU). On arrival, the norepinephrine infusion was increased to 1.8 μg/kg per minute in an effort to improve persistent blood pressures of 52/28 mm Hg with mean arterial pressure between 33 and 35 mm Hg. Within 4 hours, the patient was also given continuous infusions of epinephrine 1.0 μg/kg per minute, phenylephrine hydrochloride 10 μg/kg per minute, norepinephrine 2.5 μg/kg per minute, and dopamine 10 μg/kg per minute. Despite aggressive fluid replacement, aggressive management with vasopressor agents, and a normal ejection fraction, no significant changes occurred in the patient’s blood pressures.

Further investigation revealed that the patient most likely had ingested 400 mg of amlodipine. The PICU team concluded that the patient’s hypotension was due to the amlodipine overdose, and 3 separate infusions of 1 g of calcium chloride were administered in an attempt to outcompete the calcium channel blocker. Although the patient’s serum level of calcium increased rapidly, reaching a maximum of 19.2 mg/dL (to convert to millimoles per liter, multiply by 0.25) and an ionized calcium level of 2.57 mmol/L, her blood pressure remained alarmingly low. Additional management included intralipids and hyperinsulinemia-euglycemia (HIE) therapy. Her response was similar to her response to calcium chloride; although the insulin infusion was increased to a maximum of 65 U/h (1 U/kg per hour), mean arterial pressure remained less than 40 mm Hg.

Six hours after admission to the PICU, the patient began to show signs of cardiogenic shock, including indications of acute kidney failure and an increase in serum lactate level to 12 mmol/L. The serum level of troponin increased to 3.15 ng/mL, indicating a troponin leak most likely associated with persistent tachycardia and low diastolic pressure. An attempt to rapidly reduce circulating drug levels via plasmapheresis was started because of the long half-life of amlodipine and the patient’s resistance to vasoactive agents. Serum levels of amlodipine were checked before, during, and after plasmapheresis, along with levels in plasmapheresis fluid (see Table). Laboratory reports of the levels of the drug were received several hours after completion of the plasmapheresis and indicated a marked reduction in amlodipine concentration with the use of plasmapheresis.

Despite the reduction in the level of circulating amlodipine, the patient’s blood pressure remained critically low with doses of norepinephrine 1.8 μg/kg per minute, epinephrine 1 μg/kg per minute, phenylephrine hydrochloride 20 μg/kg per minute, and an ionized calcium level of 2.57 mmol/L. Even with the persistent hypotension and elevated troponin and lactate levels, echocardiograms continued to show normal ejection fractions, suggesting an overwhelming systemic vascular resistance index. Approximately 12 hours after admission, the decision was made to begin therapy with a military/medical antishock trouser suit, now referred to as a pneumatic antishock garment (PASG).

Use of the PASG was started by the nursing team after careful review of the most current available literature and guidance by nurses who had experience with PASGs. Immediately after the lower-extremity cuffs of the PASG were inflated, the patient’s diastolic pressure increased from 33 mm Hg to 45 mm Hg and the mean arterial pressure increased to 55 mm Hg. The PASG was inflated until an audible “crackle” of the hook and loop (Velcro) bindings occurred. Compression of the patient’s legs was released every 30 minutes for a period of 2 to 3 minutes in an effort to maintain adequate perfusion of the lower
extremities; however, each release of pressure correlated with a 5 to 10 mm Hg decrease in mean arterial pressure. By hospital day 2, the serum level of lactate was 6.9 mmol/L, and the troponin serum level was 3.15 ng/mL with continued maximum vasopressor support and PASG therapy. After 11 hours of PASG support, the team was able to deflate one leg of the suit and then the second leg because the patient’s diastolic blood pressure became increasingly responsive to vasopressor support. The patient was slowly weaned off insulin, and the troponin

<table>
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<th>Relevant medical history: previous suicide attempts</th>
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<tr>
<td><strong>Apparent overdose</strong></td>
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<tr>
<td><strong>Score on Glasgow Coma Scale (GCS), 14</strong></td>
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<tr>
<td><strong>Intentional ingestion of 400 mg of amlodipine</strong></td>
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<tr>
<td><strong>GCS score 8→intubation→administration of crystalloid fluid boluses, dopamine/norepinephrine infusions→severe refractory hypotension</strong></td>
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![Time line](image)

**Figure** Time line.

| Day 15 Transferred to an inpatient psychiatric facility for continued care |

<table>
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<tr>
<th>Emergency department</th>
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<tr>
<td>Pediatric intensive care unit admission</td>
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<tr>
<td>4 hours</td>
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<td>6 hours</td>
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<td>12 hours</td>
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<td>Day 2</td>
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<td>Day 5</td>
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<td>Day 8</td>
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Norepinephrine infusion increased to 1.8 μg/kg per minute

Continuous infusions: epinephrine, phenylephrine hydrochloride, norepinephrine, and dopamine
3 separate infusions of 1 g calcium chloride
Intralipids and hyperinsulinemia-euglycemia (HIE)

Signs of cardiogenic shock (ie, acute kidney failure and serum lactate levels increasing to 12 mmol/L) and troponin level increased to 3.15 ng/mL
To rapidly reduce circulating drug levels→plasmapheresis

Medical antishock trouser/pneumatic antishock garment (PASG) initiated

PASG support, the team was able to deflate one leg and then the second leg
The patient’s insulin infusion was slowly decreased and stopped

Patient became anuric→continuous venovenous hemodialysis (CVVH) was started

Urine output increased→CVVH was discontinued
Blood pressure stabilized on a single infusion of norepinephrine
Troponin, lactate, creatine phosphokinase, and creatine kinase–MB fraction returned to within normal limits

The patient was extubated, a steady return to baseline status→except for bilateral lower extremities paresthesias/weakness consistent with damage of anterior and posterior tibial nerves
level decreased to 2.93 ng/mL. However, on the second evening, the serum level of creatine kinase increased to 29,408 U/L (to convert units per liter to microkatals per liter, multiply by 0.0167), and the creatine kinase–MB fraction increased to 163 ng/mL. The patient gradually became anuric, and continuous venovenous hemodialysis was started on hospital day 3. At that time, the troponin level was 5.04 ng/mL (the highest so far), and the serum lactate level was stable at 5 mmol/L. By hospital day 5, urine output increased and the hemodialysis was discontinued. The patient’s blood pressures stabilized in response to a single infusion of norepinephrine, and levels of troponin, serum lactate, creatine kinase, and creatine kinase–MB fraction returned to reference values.

On day 8, the patient was extubated. During the remaining hospital stay, she experienced a steady return to baseline status, with the exception of bilateral paresthesias and weakness of the lower extremities, most likely associated with the use of the PASG. Results of electromyography and nerve conduction studies were consistent with damage of the anterior and posterior tibial nerves. The patient’s signs and symptoms resolved completely with daily physical therapy, and on day 15, she was transferred to an inpatient psychiatric facility for continued care.

Discussion

Ingestion of large amounts of calcium channel blockers results in refractory shock and can inhibit the effect of vasopressor medications such as epinephrine, norepinephrine, and phenylephrine hydrochloride in stabilizing perfusion. Among the blockers, amlodipine overdose is a cause of increased concern because of its long half-life, which leads to prolonged periods of tissue hypoperfusion.

Calcium channel blockers act by binding to the α-subunit of L-type calcium channels and reducing the influx of extracellular calcium into the cytosol. The relative abundance of the medication in the vascular smooth muscle promotes arterial dilatation, resulting in decreased blood pressure. In addition, the presence of L-type calcium channels in cardiac myocytes and the resultant blockade of calcium influx have a negative inotropic and chronotropic effect on the myocardium. With appropriate doses of amlodipine, these effects are beneficial in the management of hypertension. In excessive amounts, elimination of arterial tone causes severe hypotension and prevents the contraction of vascular smooth muscle, resulting in profound hypotension. In this patient’s case, blood pressures were so severely depressed that reflex tachycardia developed. This effect can be explained by an overdose of amlodipine.

Multiple investigators have described the use of HIE therapy to overcome the effects of overdoses of calcium channel blockers. This therapy is based on the concept that insulin prompts an opening of voltage-sensitive calcium channels, thereby providing a separate method for calcium entry into the cell and resulting in increased arterial smooth muscle contractility and improved blood pressures. In our patient, HIE therapy was ineffective, despite insulin infusion rates as high as 65 U/h and the use of dextrose-containing fluids to maintain normoglycemia. During multimodal therapy, which included HIE, the patient’s blood pressure remained dangerously low. In addition, administration of multiple boluses of calcium chloride provided little benefit. Despite high serum levels of calcium, the patient remained profoundly hypotensive and poorly responsive to vasopressor medications.

Measurements of serum amlodipine levels after toxic amlodipine ingestion have been well documented. In our patient, the measurement of amlodipine levels before and immediately after plasmapheresis indicated a marked reduction in circulating levels of the drug. Serum amlodipine levels decreased by 51% after a single cycle of plasmapheresis, and no adverse side effects occurred. On the basis of the normal half-life of amlodipine, clearance of the amlodipine without treatment would

<table>
<thead>
<tr>
<th>Time, PM</th>
<th>Time after ingestion</th>
<th>Sample</th>
<th>Amlodipine level, ng/mL&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00</td>
<td>8 h 45 min</td>
<td>Serum</td>
<td>180</td>
</tr>
<tr>
<td>9:45</td>
<td>12 h 30 min</td>
<td>Plasmapheresis fluid</td>
<td>130</td>
</tr>
<tr>
<td>11:30</td>
<td>14 h 15 min</td>
<td>Serum</td>
<td>92</td>
</tr>
</tbody>
</table>

<sup>a</sup> Amlodipine quantitation analysis by high-performance liquid chromatography, Mayo Medical Laboratories, Rochester, Minnesota.
have required in excess of 2 days. In our patient, amlodipine concentrations were markedly reduced by plasmapheresis in a short time. If the information on serum levels of the drug had been available via a point-of-care test, multiple cycles of plasmapheresis might have been attempted to further reduce the circulating concentration of amlodipine. Multiple cycles might have limited the duration of the patient’s hypoperfusion.21 Although only a single cycle of plasmapheresis was used, the circulating amlodipine levels measured in this patient suggest that plasmapheresis was a beneficial treatment. Future studies examining the use of plasmapheresis in toxic amlodipine ingestion would better define the role of that treatment.

A PASG is a self-contained inflatable abdominal girdle and/or trouser that provides increased peripheral vascular resistance.22,23 Although the garment is used rarely as a therapeutic intervention for shock, in our case it elicited a marked response and allowed maintenance of an improved blood pressure during the initial 24 hours of treatment. Immediately after inflation of the suit’s compressive trousers, a 10 mm Hg increase in diastolic pressures was noted. Because the patient already had a large increase in serum troponin levels, this increase in diastolic pressure and the resultant increase in coronary artery perfusion pressure most likely helped prevent irreversible cardiac damage. Echocardiograms performed on hospital day 2 showed no evidence of wall-motion abnormalities, and the serum troponin level declined steadily during the remainder of the patient’s hospital stay. Although myoglobinuria and neuropathic signs and symptoms developed, which were attributed to the compression of the PASG, these complications resolved before the patient’s transfer out of the PICU. The patient’s renal function returned to baseline and, with physical therapy, the peripheral neuropathies lessened. The transient nature of these side effects, compared with the high probability of demise without PASG application, clearly indicates that this treatment, although extinct in most emergency departments, provided a significant benefit in this case.

Ingestion emergencies are less common than medical emergencies, and background experience can inform difficult comprehensive care. Priorities in ingestion emergencies typically include assessing the patient, obtaining a history of medications and ingestion, initiating appropriate antidotal therapy, and depending on the patient’s state of consciousness, facilitating a cognitive psychological evaluation. Because critical care nurses may have limited exposure to treating patients who have life-threatening ingestions of amlodipine, understanding the drug’s mechanism of action and conventional treatment options can prepare them to anticipate a patient’s progress. Critical care nurses are experienced in providing and monitoring multimodal therapies and in evaluating best effects of those therapies. However, in instances in which conventional therapies are unsuccessful and unconventional therapies are prescribed, critical care nurses must understand the purpose of the therapies, safely use and monitor them, and evaluate their effectiveness. In our case, PASG was considered unconventional therapy. However, the nurses understood its purpose and quickly determined best practices for its use. They discerned from the literature safe application, inflation/deflation rates, additional monitoring requirements, and assessment of potential adverse effects.

Multimodal therapy in patients with amlodipine ingestion has been reported, but primarily in case reports.5,24,25 Therapies include HIE, intralipids, glucagon, methylene blue, and plasmapheresis. Individual responses to the amount of ingested amlodipine vary according to the patient’s previous health status and the timing of interventions to prevent cardiopulmonary collapse. The case reports indicate that critical care teams try to use conventional therapies first and then attempt unconventional therapies when a patient’s response is unfavorable. In each case, critical care nurses participated in the safe use of the therapies and in the monitoring and evaluation. In addition to supporting and educating a patient’s family, critical care nurses also coordinate multiple team members and the delivery of care (eg, coordination of plasmapheresis or continuous venovenous hemodialysis). Multimodal therapy requires constant reassessment and intervention.

Inherent to high-functioning teams are the communication of critical information and the responsiveness
to interventions. The critical care nurses in this case study promoted and maintained good communication by evaluating all aspects of the therapies delivered and ensured that the therapies were having the intended effect in the patient. The nurses also explained the use of plasmapheresis, HIE, and PASG and provided support to the patient’s family. The nurses’ communication occurred during a particularly uncertain time for survival throughout recovery.

Conclusions

As with overdoses of other calcium channel blockers, amiodipine overdose can induce profound hypotension and shock. This type of shock is a unique challenge because the inciting agent may make standard vasopressor medications ineffective. Specifically, in our case, hypotension did not respond to high-dose vasopressor agents. Moreover, although previously reported as beneficial, both HIE therapy and administration of large doses of intravenous calcium chloride were ineffective in reversing our patient’s signs and symptoms.

In contrast, removal of amiodipine via plasmapheresis and mechanical compression with a PASG were beneficial in our patient. In addition, a single cycle of plasmapheresis reduced circulating drug levels by 51%. Although not attempted in this case, multiple cycles of plasmapheresis might also have been beneficial. In addition, application of the PASG caused an instantaneous, marked increase in blood pressures. Although plasmapheresis and use of a PASG do have side effects, the adverse impact of this therapy was far outweighed by the immediate improvement in organ perfusion obtained in this patient.

Caring for patients with life-threatening ingestion requires medication knowledge, anticipation of the patients’ needs, and flexible and creative thinking when a patient is not responding to conventional therapies. In our case, the dedication to detail by the critical care nurses promoted the best possible outcomes with conventional and unconventional therapy. CCN

Acknowledgments

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Financial Disclosures

None reported.
Ingestion of laundry detergent packets is an important threat to young children. Because of their developmental stage, toddlers are prone to place these small, colorful packets in their mouths. The packets can easily burst, sending a large volume of viscous, alkaline liquid throughout the oropharynx. Ingestion causes major toxic effects, including depression of the central nervous system, metabolic acidosis, respiratory distress, and dysphagia. Critical care nurses should anticipate these clinical effects and facilitate prompt intervention. Increased understanding of the risks and clinical effects of ingestion of laundry detergent packets will better prepare critical care nurses to provide care for these children. (Critical Care Nurse. 2016;36[4]:70-75)

Laundry detergent packets are a marked risk for children whose developmental stage makes them prone to place the small colorful objects in their mouth.1-6 Ingestion of laundry detergent packets causes respiratory compromise, lethargy, nausea, vomiting, diarrhea, mucosal damage, and metabolic acidosis.1-10 Critical care nurses caring for children who have ingested laundry detergent packets should be aware of the potential for rapid deterioration in respiratory and mental status that requires prompt intervention. Additionally, nurses should anticipate the possibility of prolonged effects from mucosal damage and swelling in the oropharyngeal space.5,6 By anticipating the effects of the ingestion, nurses can intervene quickly to provide the best care possible for these children.

Background

Laundry detergent packets were introduced into the US market in 2012.1,2 The small packets are containers of concentrated detergent encased in a water-soluble membrane for a single load of laundry.1 They are known by a number of different names, which are specific to the manufacturer and the chemical preparation; Tide Pods, All Mighty Pacs, and Gain Flings are shown in the Figure. Packets have become popular because of their convenience compared with that of traditionally packaged laundry detergent.1 Their bright and colorful markings make them appear candylike, appealing to toddlers and small children, who are prone to play with and ingest or burst the packets, exposing themselves to the contents.1 Although children less than 5 years old are considered at risk, children less than 3 years old account for
the greatest number of exposures because of the younger children’s natural tendency to explore the environment by placing objects in the mouth.11 Reports of substantial toxic effects after ingestion or exposure highlight the risk that laundry detergent packets pose to children.1-10

From March 2012 to April 2013, a total of 17,230 exposures of children to laundry detergent packets were reported to the National Poison Data System.1 The number includes ocular and dermal exposures, ingestions, and aspiration.1 Rates of exposure were highest in 1- to 2-year-olds, accounting for 64.8% of all exposures.1 The most common route of exposure was ingestion alone (without any additional routes of exposure such as ocular or dermal exposure), which accounted for 79.7% of exposures; an additional 10.4% of exposures occurred via multiple routes.1 Of all children evaluated at a health care facility, children younger than 3 years or those who were exposed via ingestion were the ones most frequently admitted.1 Among children evaluated because of ingestion, almost 13% required hospital admission.1 Ingestion of laundry detergent packets is associated with a higher risk than are other routes of exposure.1,7

In data reported to the Virginia Poison Center,7 among children admitted to the hospital, 67% required intubation for central nervous system (CNS) depression, respiratory concerns, or both. Evidence of involvement of the upper part of the airway, such as stridor and drooling, was reported in 56% of cases, whereas evidence of involvement of the lower part of the airway, such as abnormal findings on lung examination, retractions, and respiratory distress, was reported in 33%. A total of 78% of patients had severe vomiting, and 22% experienced CNS depression. Additional serious reactions included gastric burns, seizures, hematemesis, pulmonary edema, bradycardia, and respiratory arrest. In 2013, two deaths due to exposure to the packets were reported, one in a 7-month-old boy and one in a 16-month-old boy.1

Laundry detergent packets were available in the European market more than 10 years earlier than in the United States, and statistics on ingestion among European children mirror those in the United States.2,3 Results of a national poison center study from the United Kingdom indicated that exposures to laundry detergent packets were the highest proportion of exposures to household cleaning products; 96% of the exposures occurred in children less than 5 years old, and 80% occurred via ingestion.2

Data from US and European studies2,3 indicated that compared with exposure to nonpacket forms of laundry detergents, ingestion of packets resulted in more signs and symptoms and increased emesis, drowsiness, coughing or choking, digestive signs and symptoms, and bronchospasm. In a comparison of exposures to packet and traditionally packaged laundry detergent reported to Texas poison centers,4 the proportion of packet exposures resulting in serious medical outcomes was more than 5 times that for exposures to traditionally packaged laundry detergent. The rates for all reported clinical effects were higher for patients exposed to packets than for those exposed to traditionally packaged laundry detergent. Surprisingly, no patients exposed to traditionally packaged detergent required intubation or had severe CNS depression, a complication that remains a major concern for patients exposed to packets.4 This finding highlights the added health risk posed by these relatively new products.

**Toxicology**

Several case reports3-10 have indicated the potential for marked toxic effects, including CNS depression, metabolic acidosis, pulmonary toxic effects, and swallowing difficulties after ingestion of laundry detergent packets.
Sudden profound lethargy is a unique feature of packet ingestion; it rarely occurs with ingestion of traditional laundry detergent. As mentioned, these signs and symptoms do not often occur with exposure to traditionally packaged laundry detergent, and the exact mechanisms of the added toxic effects remain unclear. Drawing definitive conclusions remains difficult because of variations among packets; proportions of major components are different for each manufacturer.

Several possibilities may explain the severity of the clinical signs and symptoms associated with the ingestion of packets. One possibility is propylene glycol, a component found in greater proportion in laundry detergent packets than in traditional packages. Upon ingestion, some propylene glycol is metabolized by the liver to form lactate, acetate, and pyruvate. This conversion to lactate transiently increases the serum levels of lactate, creating metabolic acidosis, which has been observed in several cases. The remainder of the drug is excreted unchanged in the urine, with renal clearance decreasing as the dose of propylene glycol increases. At higher doses, the ability of the proximal tubule to secrete the drug is exhausted and the propylene glycol remains in the blood longer. Because of this, the half-life of propylene glycol in infants and children is markedly longer than the half-life in adults; the mean half-life of 19.3 hours contributes to the propensity for toxic effects in younger patients. Toxic effects of propylene glycol are characterized by development of serum hyperosmolality, lactic acidosis, renal failure, and CNS depression. However, Beuhler et al claim that the dose contained in a laundry detergent packet should not generate enough intoxication to produce the near-coma state reported after ingestion.

A second possibility is ethoxylated alcohols. Ethoxylated alcohols are a predominate compound in laundry detergent packets and may cause sedative effects beyond the general effects of alcohol. Beuhler et al have proposed that these alcohols may account for the profound sedation observed after ingestion of laundry detergent packets. Animal studies have indicated that ingestion of relatively large doses of ethoxylated alcohols leads to profound sedation. The large doses may account for the CNS depression that occurs in children who ingest laundry detergent packets.

The final possibility is related to the higher viscosity of the contents of laundry detergent packets compared with the viscosity of the contents of traditionally packaged laundry detergent. Laundry detergent packets have a higher concentration of surfactants and ethoxylated alcohols that contribute to an increased viscosity when mixed with water. This viscous, caustic substance creates a chemical burn when it comes in contact with skin and mucous membranes and may account for the severity of airway, gastric, and corneal lesions.

Clinical Effects

Ingestions of laundry detergent packets differ from ingestions of traditionally packaged laundry detergent. The packets are likely to burst and spray contents throughout the oropharyngeal space when someone bites into them. Immediate coughing and choking are common as packets burst and laundry detergent comes into contact with esophageal, laryngeal, or bronchial tissue. Radiographs of the airway reveal swelling and edema of the epiglottic and aryepiglottic folds. Swelling of these structures narrows the airway, placing the child at risk for respiratory failure due to obstruction of the airway. Additionally, the combination of emesis and decreased mental status places the child at risk for aspiration of gastric or packet contents, resulting in pneumonia or pneumonitis. Radiographic findings consistent with aspiration pneumonia have been detected in some instances. Hypoventilation and hypoxemia ensue, sometimes severe enough to necessitate mechanical ventilation. Additionally, bronchospasm and wheezing can occur, most likely related to inflammation of the lower parts of the airway.

Lethargy

Sudden profound lethargy is a unique feature of packet ingestion; it rarely occurs with ingestion of traditionally packaged laundry detergent, and the exact mechanisms of the added toxic effects remain unclear. Drawing definitive conclusions remains difficult because of variations among packets; proportions of major components are different for each manufacturer.
packaged laundry detergent. Many case reports describe children rapidly progressing from irritability and lethargy to complete unresponsiveness and requiring intubation. In these patients, concerns for apnea or hypoventilation as well as ineffective coughing and gagging prompted intubation. In several instances, lethargy persisted for several days. In 1 case report, a child experienced lethargy, hypotonia, and diminished alertness and activity level that persisted for 7 to 10 days after ingestion. Electroencephalography and examination by a neurologist revealed no localizing neurological deficits. Upon reevaluation several weeks after discharge from the hospital, the child’s assessment findings had returned to baseline.

**Nausea, Vomiting, and Diarrhea**

Nausea, vomiting, and diarrhea are the most common signs and symptoms reported after ingestion of all household cleaning products, including laundry detergent packets. Vomiting is often the initial sign, frequently preceding or coinciding with CNS depression. The vomiting can be quite severe and may result in electrolyte abnormalities as well as dehydration. Although less common than vomiting, osmotic diarrhea sometimes contributes to the gastrointestinal distress associated with ingestion of laundry detergent packets.

**Mucosal Damage**

Because of their alkalinity, the contents of a laundry detergent packet also cause inflammation and mucosal damage, resulting in ulceration of oral, laryngeal, and esophageal tissue. In patients who had esophagogastroduodenoscopy, erythema and raised lesions were visible throughout the mucosa. Inflammation of the laryngeal and esophageal structures, essential for swallowing, speaking, and inspiration, leads to hoarseness, drooling, dysphagia, stridor, and respiratory distress. Therefore, the mucosal damage most likely accounts for some of the respiratory compromise and feeding and swallowing difficulties associated with ingestion of the packets. In some patients, dysphagia persists for days to weeks after the ingestion. These children require interventions for safe feeding, such as administration of thickened liquids or feeding via a nasogastric tube.

**Metabolic Acidosis**

Metabolic acidosis is common after ingestion of laundry detergent packets and most likely is related to conversion of propylene glycol to lactic acid. Additionally, hyperglycemia and renal insufficiency can occur. Renal insufficiency may be in part due to renal elimination of propylene glycol coupled with dehydration. Despite these reports, collection of laboratory data after ingestions of laundry detergent packets by children has been inconsistent, and further information is needed to assess the effects of the ingestions. Providers should be aware of electrolyte and metabolic derangements and the possibility of dehydration necessitating fluid administration.

**Nursing Implications**

The mainstay of management of children who have ingested laundry detergent packets is supportive care and symptomatic management as summarized in the Table. Interventions include invasive or noninvasive mechanical ventilation, intubation for airway protection, oxygen administration, hydration, use of bronchodilators, and gastric decompression. As providers at the bedside, nurses have the unique responsibility of monitoring for the most subtle changes in a patient’s status and facilitating quick intervention. Nurses caring for a child who has ingested a laundry detergent packet should be alert to the potential for rapid deterioration in the child’s clinical condition and should remain prepared to intervene as necessary.

Nurses should be aware of the potential for respiratory compromise and decline in responsiveness and should monitor for hypoxia, hypoventilation, aspiration, and inability to protect the airway. Continuous monitoring of respiratory rate and the results of pulse oximetry is essential. Noninvasive capnography monitoring may be useful in identifying hypoventilation. Nurses should assess for respiratory distress, wheezing, and stridor. Bronchodilators can be useful in patients with wheezing. Inhaled racemic epinephrine and dexamethasone can be helpful if edema of the upper part of the airway is a concern. Chest radiography may be considered for children with respiratory distress. Additionally, frequent monitoring of neurological status by determining the trend of the score on the Glasgow Coma Scale and assessing for coughing and gagging regularly are important in identifying
children who can no longer protect their airway. A plan for intubation should be discussed early because patients may progress quickly to respiratory failure or unresponsiveness and require mechanical ventilation. Nurses can advocate for the use of invasive or noninvasive positive pressure ventilation when warranted.

Patients should be given nothing by mouth and should receive maintenance intravenous fluids until vomiting resolves. Gastric decompression may provide some relief for severe vomiting and may help reduce the risk for aspiration.\(^\text{2,5,6,9,10}\) Additional administration of fluids may be required to treat and prevent dehydration associated with severe vomiting. Results of laboratory metabolic panels should be assessed to help detect electrolyte abnormalities; hydration should also be assessed. Nurses should be aware of the possibility of long-lasting mucosal inflammation and difficulties swallowing and should assess safety of oral feedings before the feedings are started. Nurses can advocate for nasogastric or postpyloric feedings to provide nutrition until the child is able to safely feed by mouth.

Of note, these management recommendations address the observed clinical effects of exposure to the contents of laundry detergent packets. The interventions have not been explicitly studied in clinical trials or specifically evaluated in research on exposure to the contents of laundry detergent packets. Many of these interventions can have unintended detrimental effects; therefore, a risk-benefit analysis should be completed before each intervention.

### Education and Awareness

Health care providers have the opportunity to prevent exposures to the contents of laundry detergent packets through educational efforts focused on prevention. Exposures are a major risk for children and are a growing problem. According to poison control center data, exposures have nearly doubled since 2012. In 2015, a total of 12,594 exposures occurred in children less than 5 years old.\(^\text{17}\) Several organizations, including the American Association of Poison Control Centers, the Centers for Disease Control and Prevention, and the American

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**Table** Pathophysiological effects of ingestion of laundry detergent packets and suggested management by system\(^a\)

<table>
<thead>
<tr>
<th>System</th>
<th>Pathophysiology</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>Cardiovascular compromise may follow respiratory, neurological, or gastrointestinal effects or fluid and electrolyte disturbances</td>
<td>Monitor heart rate, blood pressure, and perfusion</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Detergent packets burst, exposing the oropharyngeal mucosa to contents, leading to swelling and irritation Sedative effects, combined with nausea and vomiting, increase risk for aspiration Sedative effects may lead to apnea or hypoventilation</td>
<td>Monitor work of breathing, respiratory rate, and pulse oximetry Consider noninvasive capnography monitoring Monitor for stridor and have racemic epinephrine and dexamethasone available Monitor for wheezing and have albuterol available Consider chest radiography Maintain plan for intubation</td>
</tr>
<tr>
<td>Neurological</td>
<td>Components of the detergent, specifically ethoxylated alcohol and propylene glycol, may produce marked lethargy, which can lead to hypoventilation, apnea, or inadequate secretion management Although the mechanism is poorly understood, seizures have been reported</td>
<td>Track trends in scores on Glasgow Coma Scale; consider intubation if score &lt;8 Assess cough and gag reflex regularly Monitor for seizure activity</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>Ingestion can lead to marked nausea and vomiting Oropharyngeal mucosal damage may lead to dysphagia</td>
<td>Maintain nothing by mouth Use gastric decompression Do a swallowing evaluation when appropriate Give nasogastric/postpyloric feedings if necessary</td>
</tr>
<tr>
<td>Fluid and electrolytes</td>
<td>Electrolyte disturbances and dehydration may result from vomiting as well as metabolism of propylene glycol</td>
<td>Administer maintenance intravenous fluids Monitor hydration status and consider additional fluid bolus Monitor results of laboratory metabolic panel</td>
</tr>
</tbody>
</table>

\(a\) Intervention recommendations are based on the observed clinical effects of ingestions. These interventions have not been specifically studied in regards to pediatric exposure to laundry detergent packets.
Academy of Pediatrics, have launched campaigns to educate consumers about the risks associated with laundry detergent packets. Additionally, many manufacturers are now distributing packets in opaque containers with latches that are difficult for children to open.

Creating awareness among parents of young children is essential to reducing ingestions. Parents of young children, especially toddlers 1 to 2 years old, should be educated frequently about the risks associated with ingestions of laundry detergent packets and should be encouraged to store the packets out of the reach of children. Parents of especially high-risk children can be encouraged to store the packets out of the reach of children. The colorful appearance of laundry detergent packets makes them appealing to young children, who often explore the environment through oral play. When placed in the mouth, laundry detergent packets can burst and spray their contents throughout the oropharynx, causing mucosal irritation. Children may ingest or aspirate the contents, leading to marked toxic effects that often require admission to an intensive care unit, mechanical ventilation, and close monitoring. Pediatric critical care nurses should anticipate the clinical effects of ingestion of laundry detergent packets so the nurses can promptly intervene when needed. Prompt recognition of respiratory distress and changes in mental status are necessary to keep these children safe. Moreover, nurses can make an impact in preventing ingestions by educating families with young children on the risks associated with laundry detergent packets.

**Conclusion**

The colorful appearance of laundry detergent packets makes them appealing to young children, who often explore the environment through oral play. When placed in the mouth, laundry detergent packets can burst and spray their contents throughout the oropharynx, causing mucosal irritation. Children may ingest or aspirate the contents, leading to marked toxic effects that often require admission to an intensive care unit, mechanical ventilation, and close monitoring. Pediatric critical care nurses should anticipate the clinical effects of ingestion of laundry detergent packets so the nurses can promptly intervene when needed. Prompt recognition of respiratory distress and changes in mental status are necessary to keep these children safe. Moreover, nurses can make an impact in preventing ingestions by educating families with young children on the risks associated with laundry detergent packets.

**References**

I wrote this column while recovering at home from what is my fifth surgery for breast cancer. The first 4 procedures were during the year of my diagnosis and initial treatments, and this one is a revision of my reconstructive surgery. My situation reminded me that life does not stop while one is recovering from illness or while a nurse is preparing to take a certification exam. I have an incredibly supportive husband and hospital job, and complete control over my schedule, but I have still had periods of feeling overwhelmed and questioning why the heck I had this elective surgery. For most nurses, preparing for and achieving certification is elective and not without stress, self-doubt, and questioning why. Responsibilities related to work, family, and life in general continue, despite one’s taking on the professional/personal goal of certification. What has worked for me in this situation—and has worked for me in the past—is to take deep breaths, focus on the goal, have a plan, and take it one step at a time. And if you find it necessary, remember that it is okay to ask for and to accept help.

**CCRN Practice Questions**

1. A patient is receiving fluid resuscitation for hypovolemic shock. In the past 90 minutes, the bladder pressure has changed from 15 mm Hg to 27 mm Hg. Fluid resuscitation should continue because
   A. The patient’s intra-abdominal hypertension (IAH) has to be treated
   B. The patient is probably now back in an aerobic metabolism
   C. The lactate level, which was 7 mg/dL, is probably lower now
   D. The fluid resuscitation should continue past 30 mL/kg

Test plan topic: Multisystem, 14% of the CCRN questions

2. A postoperative intubated patient wakes up very anxious and combative. The patient mouths the words “My wife, my wife!” The nurse is aware that his wife died in the operating room following the motor vehicle crash. The best response by the nurse would be
   A. “Mr Jones, I will find out about your wife, but please first answer a few questions for me.”
   B. “Sir, you are in the ICU [intensive care unit], I need you to calm down before you hurt yourself.”
   C. “Mr Jones, I’m sorry to tell you this but your wife died in the operating room.”
   D. “I cannot read lips well, but if you relax, we can get that tube out sooner so we can talk.”

Test plan topic: Caring practices is one of the nurse characteristics of the synergy model, Professional Caring Practices, 20% of the CCRN questions

3. A patient who arrived an hour ago with acute abdominal pain and probable sepsis has been confirmed to have a bowel perforation with peritonitis. After giving telephone consent for surgery, the spouse asks why the surgery is an emergency. The best response would be
   A. “We hope the surgery will save his life.”
   B. “The infectious material from within the bowel is spilling into his peritoneum.”
C. “This type of bowel problem and infection must be controlled as quickly as possible.”
D. “If he had come into the hospital sooner, surgery might not have been necessary.”

Test plan topic: Gastrointestinal is part of GI, Renal, Heme/Immune, Endocrine, and Integumentary, which are 20% of the CCRN questions

4. Which of the following sets of clinical signs best describes the assessment findings anticipated with a hemoglobin level of 6.2 g/dL?
A. Tachycardia, hypotension, hyperthermia
B. Tachycardia, hypotension, oliguria
C. Bradycardia, hypertension, tachypnea
D. Hyperglycemia, hypotension, bibasilar rales

Test plan topic: Hematology/Immunology is part of GI, Renal, Heme/Immune, Endocrine, and Integumentary, which are 20% of the CCRN questions

5. A patient arrives unresponsive with a glucose level of 38 mg/dL. Which findings in the patient’s medical history could be contributing factors?
A. A history of alcohol abuse and sertraline daily for depression
B. A recent infection and prednisone daily for chronic obstructive pulmonary disease (COPD)
C. Discharged 2 weeks ago after having an inferior wall myocardial infarction (MI) and metoprolol daily
D. Symptoms of a urinary tract infection (UTI) and insulin for type 1 diabetes

Test plan topic: Endocrine is part of GI, Renal, Heme/Immune, Endocrine, and Integumentary, which are 20% of the CCRN questions

Correct Answers and Rationales for CCRN Practice Questions

1. Correct Answer: D
Rationale
Normal abdominal pressure is 0 to 5 mm Hg. Decreased abdominal perfusion occurs in shock. Intra-abdominal (bladder) pressure will increase with decreased perfusion because of ischemia, injury, and inflammation. The bladder pressure and lactate levels will decrease when the shock state is being resolved during resuscitation. If the pressures are still increasing, the patient needs continued and possibly more aggressive resuscitation. IAH (A) would be a sustained pressure of greater than 12 mm Hg, and when the patient returns to an aerobic metabolism (B), the bladder pressure and lactate level (C) will come down.

Source

2. Correct Answer: A
Rationale
When a patient wakes up from surgery anxious and combative, it is important to assess airway, pain, and orientation. Using his name and acknowledging his question might help to calm him down. Ignoring his question (B) or telling him the truth (C) before it is established that he is oriented to his current situation might increase his anxiety. It is always a good policy to tell the truth.

Source

3. Correct Answer: C
Rationale
All 4 of the statements might be true responses to the question. Option C is the best choice because it uses words that are common like infection, controlled, and quickly. The statement is clear and directly answers the question the spouse has asked. This is especially important when the conversation is on the phone, with a family member who has just received bad and scary news.

Source

4. Correct Answer: B
Rationale
The decreased oxygen delivery that occurs with anemia activates a compensatory response leading to tachycardia, tachypnea, oliguria, and hyperglycemia. The anemia, if accompanied by low blood volume, will cause hypotension despite the vasoconstriction. Hyperthermia (A), bradycardia (C), and bibasilar rales (D) would not be present in a hypovolemic state.

Source
5. Correct Answer: A  
Rationale  
Both alcoholism and sertraline can cause hypoglycemia. Infection (B, D) typically causes hyperglycemia. Steroids can cause hyperglycemia, whereas β-blockers (C) cause hypoglycemia.

Source  

CSC Practice Questions

1. Twenty hours after chest reexploration for bleeding and a massive transfusion of blood products, a patient has suspected development of transfusion-related acute lung injury (TRALI). Assessment data that would be consistent with this diagnosis include which of the following? (Abbreviations: bpm, beats per minute; F\textsubscript{IO}2, fraction of inspired oxygen; HR, heart rate; PIP, peak inspiratory pressure; S\textsubscript{v}O\textsubscript{2}, venous oxygen saturation)

   \[
   \begin{array}{|c|c|c|c|}
   \hline
   \text{Pao}_2/\text{FiO}_2 & \text{HR, bpm} & \text{SvO}_2 \text{, } \% & \text{PIP, cm H}_2\text{O} \\
   \hline
   \text{A.} & 175 & 102 & 40 & 41 \\
   \text{B.} & 275 & 64 & 50 & 30 \\
   \text{C.} & 375 & 96 & 60 & 37 \\
   \text{D.} & 475 & 73 & 70 & 24 \\
   \hline
   \end{array}
   \]

   Test plan topic: Other Patient Care Problems (pulmonary: acute respiratory distress syndrome [ARDS]), 24% of the CSC questions

2. Upon taking responsibility for a patient 10 hours after quadruple coronary artery bypass graft (CABG), a nurse assesses the following data:  
   - HR: atrial fibrillation (A-fib) 127 bpm
   - Blood pressure (BP): 167/82 mm Hg
   - Mean arterial pressure (MAP): 110 mm Hg
   - Pulmonary artery pressure, systolic/diastolic (PAS/PAD): 52/31 mm Hg
   - Pulmonary artery occlusion pressure (PAOP): 13 mm Hg
   - Body temperature: 37.3°C
   - Extubated with respiratory rate (RR): 26/min

   What in the patient’s medical history has most likely contributed to this assessment data?
   A. Type 2 diabetic
   B. Heavy smoker for 20 years
   C. Family history of coronary artery disease (CAD)
   D. Metoprolol 50 mg daily

   Test plan topic: Cardiovascular Patient Care Problems (complications of cardiac surgery: pulmonary hypertension), 33% of the CSC questions

3. During multidisciplinary rounds, the respiratory therapist asks if it would be appropriate to attempt a spontaneous breathing trial (SBT) today on a patient 40 hours after type I acute aortic dissection repair and aortic valve repair (AVR). Which treatment change in the last 24 hours would support an SBT?
   A. F\textsubscript{IO}2 decreased from 90% to 75%
   B. Norepinephrine decreased from 5 to 3 μg/min
   C. Continuous renal replacement therapy (CRRT) discontinued yesterday
   D. Patient weaned off of propofol and calm

   Test plan topic: Interventions (pulmonary, ventilator weaning), 33% of the CSC questions

4. Which of the following assessment information would be consistent with heparin-induced thrombocytopenia (HIT)?
   A. pH, 7.27; Pa\textsubscript{CO}_2, 30 mm Hg; HCO\textsubscript{3}, 15 mEq/L
   B. Development of acute thrombosis
   C. Elevation in levels of alanine aminotransferase (ALT) and aspartate aminotransferase (AST)
   D. Family history of thrombotic thrombocytopenic purpura (TTP)

   Test plan topic: Other Patient Care Problems (hematology/immunology: HIT), 24%

5. Three hours after arriving in the cardiovascular ICU (CVICU) after a maze procedure, a patient has the following assessment. (Abbreviations: CVP, central venous pressure; MAP, mean arterial pressure; NSR, normal sinus rhythm; PRI, PR interval; UO, urine output)

<table>
<thead>
<tr>
<th>On admission</th>
<th>3 hours later</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR, bpm</td>
<td>102, NSR</td>
</tr>
<tr>
<td>MAP, mm Hg</td>
<td>142/75</td>
</tr>
<tr>
<td>PAP, mm Hg</td>
<td>25/11</td>
</tr>
<tr>
<td>CVP, mm Hg</td>
<td>14</td>
</tr>
<tr>
<td>UO, mL</td>
<td>0</td>
</tr>
</tbody>
</table>

   The nurse should prepare to do which of the following?
   A. Administer a normal saline bolus
   B. Begin a norepinephrine infusion
Test plan topic: Cardiovascular Patient Care Problems (surgical treatment of cardiac rhythm disorders—maze), 33% of the CSC questions

Correct Answers and Rationales for CSC Practice Questions

1. Correct Answer: A
   Rationale
   TRALI causes ARDS from antigen/antibody reaction between the donor blood and the recipient, leading to a systemic inflammatory response syndrome (SIRS).
   ARDS manifests as a PaO₂/FiO₂ of 300 to 400 (mild), 200 to 300 (moderate), 100 to 200 (severe), and an increasing PIP. In the absence of CAD or β-blocker administration, the heart rate would typically increase. In ARDS, oxygen demands are high, delivery is low, extraction is high, Svo₂ is low, and the PIP increases as alveolar compliance decreases.

   Source

2. Correct Answer: B
   Rationale
   The chronic hypoxia from smoking can lead to the development of pulmonary hypertension, increased right ventricular afterload, atrial stretching, and A-fib. Pulmonary hypertension is one condition in which the PAD is higher than the PAOP. Diabetes (A) and a family history of CAD (C) are risk factors for systemic hypertension and CAD development. Administration of metoprolol (D), a selective β₂-blocker, before surgery would contribute to decreased HR and BP.

   Source

3. Correct Answer: D
   Rationale
   Ventilator weaning is a multidisciplinary intervention, and spontaneous awakening and breathing trails are part of the ABCDEF bundle. The patient must meet certain clinical criteria such as the minimal requirements for mechanical ventilation (A), vasoactive (B) and sedative support, and hemodynamic stability. Renal function (C) is not a criterion unless renal dysfunction is causing cardiac or pulmonary instability.

   Source

4. Correct Answer: B
   Rationale
   HIT is an acquired allergic reaction to the animal protein antigen in heparin. The patient’s immune system creates an antibody that then “attacks” the heparin antigen on the surface of the platelet, causing platelet activation (clotting) and destruction (thrombocytopenia). Metabolic acidosis (A) and liver failure (C) both can cause a decrease in platelet count and increased risk for bleeding—not clotting. A family history of TTP (D) does not increase the likelihood of someone having HIT.

   Source

5. Correct Answer: C
   Rationale
   Postoperative development of heart block is common in maze procedures. The goal of creating the surgical maze, leaving only 1 electrical pathway between the sinoatrial (SA) and atrioventricular (AV) nodes, is sometimes slow or blocked in the initial postoperative period. The bradycardia and hypotension would be managed first with atrioventricular (A-V) pacing. A fluid bolus (A) and norepinephrine (B), an α-receptor stimulator, could both increase the BP, but the current problem is most likely due to bradycardia and heart block. Atropine (D) administration would be very short acting and also unpredictable in a patient who has undergone a maze procedure.

   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

Nurse-Administered Sedation

Q

I’ve read that certain state boards of nursing permit nurses to administer propofol, etomidate, and paralytic agents during intubation or procedures at the bedside in the presence of an anesthesia provider. What is the best practice? How is it determined whether a nurse can give these medications?

A

Catherine Ewing, RN, BSN, replies:

The scope of this nursing practice varies by state. Within the Nurse Practice Act, each state board of nursing determines whether it is acceptable for registered nurses to administer such medications while determining a framework of application, within its jurisdiction, to ensure patient safety. As of 2015, more than a dozen states do not allow nurses to administer propofol. It is important to be aware of how your state board of nursing defines the scope of practice of registered nurses and to recognize timelines for review and updates.

Certain requirements must be met before administering medications that are classified as anesthetics. The board of nursing in each state provides a guidance statement enumerating the requirements for nurses to administer anesthetics. This statement may include, but not be limited to, the following skills to be obtained by the registered nurse:

- Adequate assessments before, during, and after the procedure, including assessments of vital signs, level of consciousness, and oxygen saturation (ideally capnography), cardiac monitoring, and airway patency
- Possession of current clinical competence, including knowledge, judgment, and skill
- Appropriate selection and assignment of patients
- Familiarity with the medication and its safe administration
- Competence in use of all age-appropriate equipment, including intubation, nasal and oral airways, bag-valve mask, suction, oxygen source availability, and circulatory arrest devices

Appropriate pharmacology
- Recognition of complications if they arise
- Verification of current policies and procedural guidelines of the employing medical facility
- Compliance with federal and state laws and rules

These medications have a substantial list of intended uses and side effects. Side effects may include cardiac arrhythmia, hypotension, apnea, and respiratory acidosis. Changes in patients’ status may occur rapidly. The Institute for Safe Medication Practices (ISMP) has a long history of heightening awareness and risk that these types of medications may cause harm to patients. Error reports are submitted to a program that identifies which drugs are most often associated with error. A list of high-alert medications is updated regularly. The ISMP includes propofol as a high-alert medication within the anesthetic agent category. Patients may suffer significant harm if this medication is used and an undesired effect or error occurs. No reversal agent is available for propofol.

Some medical facilities have models of anesthesia care that include a combination of anesthesiologists and registered nurses. In a retrospective review, Erie and colleagues...
reported safe outcomes of propofol administration with an anesthesiologist supervising and a nurse monitoring sedation during cataract surgery. Very few complications occurred, and the anesthesiologist had to intervene during the surgery in only 1.5% of cases. Hypotension was the most common reason for intervention by the anesthesiologist.

Each organization should assemble a multidisciplinary team to develop and implement a policy and procedure on conscious sedation and analgesia. The expertise of various members of the care team facilitates the organization of roles and responsibilities to those providing this type of care to patients. These members may include anesthesiologists, advance practice registered nurses, registered nurses, registered pharmacists, and respiratory therapists. These members will ensure that safe administration and practice will occur during multiple possible patient scenarios. Any outcomes achieved by a team would need approval by the pertinent governing boards. Reviewing of these types of policies is determined by each medical institution. The American Society of Anesthesiologists is also a very suitable reference to use for standards, guidelines, and practice parameters when developing policies and procedures.

In conclusion, awareness of policies and procedures is imperative to maintaining patient safety while delivering quality care. All nurses should be familiar with their state’s Nurse Practice Act (https://www.ncsbn.org/npa.htm).

References

Financial Disclosures
None reported.

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Cochrane Review Summary

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

Short-Course Versus Prolonged-Course Antibiotic Therapy for Hospital-Acquired Pneumonia in Critically Ill Adults

Cass Piper Sandoval, RN, MS, CCRN, CCNS

Review Question

This review sought to assess the effectiveness of short versus prolonged-course antibiotics for hospital-acquired pneumonia (HAP) in critically ill adults, including patients with ventilator-associated pneumonia (VAP).1

Relevance to Critical Care Nursing

HAP is a frequent nosocomial infection in hospitals worldwide, and the most common hospital-acquired condition in the intensive care unit (ICU). More than 90% of HAP cases in the ICU occur in patients who are intubated and receiving mechanical ventilation, making VAP the most significant contributor to the problem.2 National treatment guidelines from the Infectious Diseases Society of America, the American Thoracic Society, and the British Society for Antimicrobial Chemotherapy are 8 to 10 years old, and numerous studies have been done in the interval. In addition, the definition of VAP is an area of current debate. The authors of this Cochrane Review sought to include the most recent evidence evaluating the optimal duration of antibiotic therapy, a key consideration in the treatment of HAP. If therapy is too short, clinicians risk recurrence of infection; however, prolonging treatment unnecessarily also has risks including the development of resistant organisms, *Clostridium difficile* infection, antibiotic-related toxic effects, and increased drug and hospital costs.

Study Description and Results

Studies selected for this review included only randomized controlled trials of antibiotic therapy for HAP for fixed durations. Participants were ICU patients (16 years and older) with HAP (including VAP) diagnosed by clinical, radiologic, and/or quantitative culture. Those with hematologic malignant neoplasms, chemically induced immune suppression, or HIV/AIDS were excluded when possible. The intervention of interest was comparing antibiotic therapy of “short” duration (≤ 8 days) with “prolonged” duration (typically 10-21 days). Primary outcome measures included 28-day mortality, recurrence of pneumonia, and number of antibiotic-free days in a 28-day period. Secondary outcomes included ICU and in-hospital mortality, clinical resolution of pneumonia, relapse of pneumonia, subsequent infection due to “resistant organisms,” duration of ICU and hospital stay, duration of mechanical ventilation, mechanical ventilation-free days, and mortality attributable to HAP.

Two review authors independently screened abstracts, assessed full texts using a standardized data extraction form, assessed for risk of bias, and resolved any disagreements by discussion. Six studies met inclusion criteria, with a total of 1088 participants from medical, surgical, cardiothoracic, and neurosurgical ICUs in Africa.
Asia, Europe, and North, Central, and South America. Five of these were randomized controlled trials (RCTs) comparing antibiotic durations in VAP patients, while the sixth was an RCT that compared a 3-day course with “standard” antibiotic therapy duration in patients with low probability of HAP (58% were receiving mechanical ventilation). Data from the latter were not included in the meta-analysis because of the differences in study population.

Dichotomous data were analyzed by calculating the odds ratio (OR), whereas continuous data were analyzed by using mean difference (MD), each with 95% confidence intervals (CI). The reviewers used a random-effects model for meta-analysis because of the diversity in study characteristics and assessed heterogeneity by using the I² statistic.

Summary of Main Results

- In general, there was large variation in the type of participants, the diagnostic criteria used for pneumonia, the interventions, and the reported outcomes, which led to a small number of studies contributing to a particular summary statistic.

- For patients with VAP, a short course of antibiotic therapy (7-8 days) compared with a prolonged course (10-15 days) had more antibiotic-free days in a 28-day period and a reduced recurrence of VAP due to multidrug-resistant organisms with no adverse impact on mortality or other recurrence outcomes (antibiotic-free days: 2 studies, N = 431, MD 4.02 days, 95% CI 2.26-5.78 days; recurrence of multidrug-resistant organisms: 1 study, N = 110; OR 0.44, 95% CI 0.21-0.95).

- For cases of VAP due to non-fermenting gram-negative bacilli (NF-GNB), recurrence occurred more often after a short course of therapy, although mortality outcomes were not significantly different (2 studies, N = 176, OR 2.18, 95% CI 1.14-4.16).

- For critical care patients with suspected HAP but low probability of pneumonia according to their Clinical Pulmonary Infection Score, discontinuing therapy at day 3 had a reduced composite rate of superinfection and antimicrobial resistance, and reduced duration of ICU stay (OR 0.29, 95% CI 0.09-0.92, ICU stay SD not reported; P = .04).

- No significant differences between short or prolonged therapy were found in ICU mortality, in-hospital mortality, clinical resolution, relapse, duration of hospital stay, duration of mechanical ventilation, or number of mechanical ventilation–free days.

- The overall quality of evidence was rated as low to moderate by using Cochrane’s GRADE classification. This rating was due to the large variations between studies, significant bias in 2 studies, and contamination of controls with early termination in 1 study.

Nursing Implications

Critical care nurses are optimally positioned to advocate for antibiotic stewardship. Being knowledgeable about which patients may benefit from a short versus a prolonged course of antibiotic therapy can help reduce the burden of HAP for patients as well as the larger community. The available evidence on antibiotic duration for HAP in critically ill patients should be interpreted with caution, however, owing to the low number of studies with low to moderate quality. There is little evidence on nonventilated patients with HAP. For patients with VAP, short-course antibiotic therapy appears to be safe, except in those patients with VAP due to NF-GNB (ie, Pseudomonas aeruginosa, Acinetobacter spp), where longer courses may be required for clinical resolution. Further research on optimal duration in NF-GNB VAP patients is needed.

Financial Disclosures

None reported.

References


This book is an excellent read for clinicians who seek a better understanding of electronic health record functionality, for information technology experts who need to comprehend the unique business of health care, and for health care consumers grappling with the impact of technology on their experiences. On a superficial level, Dr Wachter’s description of providers frustrated with electronic health record implementation is reassuring. On a deeper level, the book’s explanation of the diverse and complex applications of health care technology—to ensure correct billing, to avoid malpractice issues, to meet federal requirements—lends a concern that the welfare of patients is only a single entity in a long list of priorities. Fortunately, patient care is clearly at the forefront of Dr Wachter’s analysis.

The author’s unique and powerful understanding of the complexity of health care and information technology is exemplified in the following quote:

“One of the great challenges in healthcare technology is that medicine is at once an enormous business and an exquisitely human endeavor; it requires the ruthless efficiency of the modern manufacturing plant and the gentle handholding of the parish priest; it is about science, but also about art; it is eminently...”

Dr Wachter deftly explains the complex interaction of medicine and information technology. The book is meticulously researched, including interviews with a diverse assortment of frontline clinicians, information officers, and policy makers, as well as background research on the evolution of medical documentation. Going beyond an analysis of work flow, Dr Wachter also details the impact of information technology on physicians’ relationships with their patients and their colleagues.

The book is divided into 6 parts, the first giving the history of medical documentation, and the last, a view on what the future holds as information technology is increasingly embedded in health care delivery. The middle sections each describe a different mechanism by which information technology affects health care. What makes this book captivating is that in all sections, Dr Wachter uses clinical examples, from his own experience and the narratives of those he interviewed, to bring the concepts to life. The best example is in part 3, in which he dissects the sequence of events that lead to a medical error, graphically illustrating the tragic limitations of electronic systems in guaranteeing patient safety.

Though Dr Robert Wachter is known for coining the term “hospitalist” and launching a new medical specialty, this book is his sixth and he is clearly an author whose talents go far beyond that simple sound bite. In The Digital Doctor,
quantifiable and yet stubbornly not.

This book is an insider’s view that will resonate with all members of the health care team.

Sarah Delgado is a clinical practice specialist at the American Association of Critical-Care Nurses in Aliso Viejo, California.

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When Breath Becomes Air

This book is a memoir by a neurosurgeon who, as he was nearing the end of his residency, was diagnosed with stage 4 lung cancer. In the first part of the book, the author describes his decision to pursue a medical career. With references to classical texts, he discusses how he began his search to understand death and morality through literature, and ultimately concluded that he needed clinical experiences to effectively explore these issues. The second part of the book describes his diagnosis and the painful transition from a doctor who observes suffering to a patient who experiences it. What is most uplifting about this book is the author’s consistent emphasis on the value of health care that recognizes the person and his or her goals, not just the disease and its trajectory.

Pharmacology Case Studies

This book offers a unique case-based approach to pharmacology content. Each chapter includes one or more cases and a discussion of the rationale for selecting specific agents to manage the identified diagnosis. The authors address a variety of topics including psychiatric disorders, heart failure, postanesthesia and perioperative care, and substance use disorders. In discussing the management of various health problems, the authors do not confine their discussion to pharmacologic interventions. The inclusion of nonpharmacologic care is best emphasized in the final chapter on holistic nursing care.

Overall, this is a nice supplement to a pharmacology course or as a refresher for advanced practice nurses looking to reaffirm their understanding of the pharmacologic management of specific disorders. CCN

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Florida
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TCRN Review Course
Date: October 21-22, 2016. Place: Nova Southeastern University. Address: 8585 SW 124th Ave, Miami, FL 33183. Keynote Speaker: Kendra Menzies. Sponsor: Greater Miami Area Chapter of AACN. Contact: Ruth Salathe. Phone: (305) 866-4203. E-mail: ruthsalathe@gmail.com. Fee: Members, $180; nonmembers, $193; groups of 3, $170 each (applies only if registrations received together). Credits: 14 CEUs

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Critical Care Nursing: Visioning Beyond the Basics
Date: September 11-13, 2016. Place: Marriott-Century Center in Atlanta, GA. Keynote Speaker: Clareen Wienczek. Sponsor: Region 6 Chapters of AACN. Contact: Tammy Carter. Phone: (706) 564-2015. E-mail: tcartel1@augusta.edu. Fee: Please contact for fee information. Credits: 11.5 CEUs

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Annual Chapter Symposium Nursing in the New Millennium: Basing Your Practice on the Evidence
Date: October 14, 2016. Place: Baptist Health Louisville. Address: 4000 Kresge Way, Louisville, KY 40207. Keynote Speaker: Kathleen Vollman. Sponsor: Greater Louisville Chapter of AACN. Contact: Deb Tuggle. Phone: (502) 500-5010. E-mail: deborahjtuggle@gmail.com. Fee: Member, $60; nonmember, $75; student (prelicensure), $25. Credits: 7.5 CEUs

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Why did you become a nurse?

The first time I set foot in a hospital was when, a month early, my son was miraculously delivered. My wife suffered a near-fatal amniotic fluid embolism and I became a parent and nearly a widower in the same moment. As my wife lay in a coma fighting for her life, I was schooled about the various units, specialists, diagnostic tests, laboratory, pathology, social workers, administration, risk management, spiritual care, occupational and physical therapy, and even pet therapy. As the days went by, my wife’s survival went from unlikely to possible, then to probable, and, finally, to discharge. We continued to stay in touch with the incredible nurses and clinicians who so competently and lovingly cared for my son and wife. During a visit back to the neonatal intensive care unit and intensive care unit I realized the hospital had become a second home. Later that night I talked to my wife about going back to school to become a nurse. I knew it would be a stretch for us financially, emotionally, and physically, but I felt I had a calling to become a nurse.

What about your job as a nurse makes you happy?

I enjoy the challenge of helping a critical and unstable patient return to a state of good health. Having been on the other side, I also find joy and satisfaction in helping the patient’s family and sharing my own story.

Tell us about an extraordinary experience you’ve had as a critical care nurse.

I would say it is working alongside and gaining the respect of the very same nurses and physicians who saved my wife and son. Sometimes I wonder how I ended up where I am today and then I remember that pinnacle moment. It most often happens when I am in the room where my wife recovered.

What are the challenges you encounter and how do you overcome them?

Helping family members accept their loved ones’ diagnosis and prognosis can be challenging. I make sure to include all family members in the care of my patients whenever possible. Sharing my story helps me communicate with family members in a supportive way.

What has your journey as a nurse been like?

My journey to become a nurse is unique. Not too many contractors decide to switch careers at nearly 35 years old.

At the end of a busy day, how do you find balance in your life?

I like to reflect on how I ended up where I am. It reminds me why I chose this profession. I enjoy an active and healthy lifestyle. I love to play with my son and take advantage of all our beautiful city has to offer. We hike, golf, and spend time at the beach.

What would we be surprised to know about you?

I grew up in the Cayman Islands. I was born in Canada but my parents sought warmer weather and moved when I was 3 years old. Some days I missed school because there was a pod of dolphins in front of our house and my dad felt I would learn more swimming than I would in the classroom.

How has AACN played a role in your career?

Shortly after graduation, I became an AACN member. I look forward to receiving the journals and I read them cover to cover. I often incorporate what I read into my practice. At NTI, the classes, exposition, and posters keep me up to date on the latest information on critical care nursing. I consider myself a lifelong learner and AACN helps satisfy my need to learn. The articles and resources allow me to be the best nurse I can possibly be.
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