Research at the Bedside: It Makes A Difference

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Moral Distress, Moral Courage

By Richard H. Savel, MD, and Cindy L. Munro, RN, PhD, ANP

Working with colleagues on a multidisciplinary intensive care unit (ICU) team is a noble endeavor. Similarly, providing high-quality, coordinated care to patients who are deathly ill, snatching them from the jaws of death and reuniting them with their loved ones and with a functional life, is both personally and professionally rewarding—that is, when things go well.

Unfortunately, sometimes things do not go so well. Sometimes we know what we want to do, but we’re unable to execute our desired action plan. Perhaps it’s because we’re providing care we deem inappropriate. Or maybe we believe families are being given false hope. These pangs we feel needn’t be patient related, however: anytime our moral compass is being spun against our will, we feel wounded. We go home feeling a terrible combination of anger, fear, confusion, and powerlessness.

That noxious emotional concoction has a name: moral distress.

To battle moral distress, one must understand that it exists, understand what it is, and understand that there are structured approaches to help recognize and manage the problem.

In this editorial we discuss the concept of moral distress and consider ways to alleviate it. For readers who are new to the topic, we hope you find the information valuable for improving the quality of your professional life. If you’re already familiar with this topic, we hope our editorial inspires you to share what you know with colleagues, paying it forward.

In what follows we’ll discuss moral courage as a partner concept to moral distress. Also, we will provide some cognitive strategies to help improve one’s ability to recognize moral distress and to develop skills that strengthen moral courage.

Moral Distress

Initially described by Andrew Jameton in 1984, moral distress is defined as "knowing what to do in an ethical situation, but not being allowed to do it." Numerous examples of moral distress emerge in everyday clinical practice including continued life support, even when it may not be in the best interests of the patient; inadequate communication about end-of-life care among providers, patients, and families; inappropriate use of health care resources; inadequate staffing; and false hope given to patients and families. A key component in recognizing moral distress is a sense of powerlessness.

These constraints can be internal, such as anxiety or self-doubt about creating conflict, or external, related to power imbalances in the workplace. One can distinguish between a moral dilemma, in which there are multiple choices to make and the correct path may not be clear, and moral distress, in which the path is clear, but the ability to implement a solution is somehow blocked.
In 2004, the American Association of Critical-Care Nurses published *The 4A's to Rise Above Moral Distress* to help clinicians recognize and address moral distress. In this document, the 4A's are presented to help combat the frustrations in these complex situations: ask, affirm, assess, and act. We will go into some detail below.

**Stage 1**

Ask. Here, the question is, “Am I, or any members of my team, feeling symptoms or showing signs of suffering? Have coworkers, friends or family members noticed these signs and behaviors in me?” This paradigm divides the types of responses into 4 major groups: physical (e.g., fatigue, exhaustion, lethargy, impaired sleep), emotional (e.g., anger, fear, guilt, confusion, anxiety), behavioral (e.g., addictive behavior, controlling behaviors, apathy, indifference, depersonalization), and spiritual (e.g., loss of meaning, crisis of faith, loss of control and self-worth, disconnection with people or work community). The goal here is to become aware that moral distress is present.

**Stage 2**

Affirm. Here the focus is on one's commitment to care for self. The emphasis is on the professional responsibility for the creation of a healthy work environment. It is important to validate feelings and perceptions with others. This recommended approach goes all the way up to the ANA Code of Ethics: “The nurse owes the same duties to self as to others, including preservation of personal integrity and wholeness of character.” The goal of this stage is to make a commitment to address moral distress.

**Stage 3**

Assess. This stage involves identifying the source or sources of moral distress. Is it related to a particular patient situation? A unit policy? A lack of collaboration? One also should determine the severity of the distress on a scale of 0 to 5. The 4A's document has some structured exercises to help determine the risk/benefit score for a particular situation. The goal at this stage is to be ready to make an action plan.

**Stage 4**

Act. This stage involves creating and implementing an action plan. The goal is to preserve your integrity and authenticity. Although the action plans will vary depending on the problem to be solved, some “big picture” strategies include remaining true to yourself and remembering that caring for yourself mentally, physically, and spiritually is of the utmost importance; being an advocate for your patients at all times; identifying and working with a leader in your unit; anticipating and managing setbacks; and continuously reevaluating.

**Moral Residue**

Once an event that causes moral distress is over, the health care professional does not go back to his or her moral baseline afterwards. This is called moral residue and refers to the fact that each time a morally distressing situation occurs and resolves, the level of residual moral distress continues to rise. Another way of looking at this concept is that moral distress can linger and, unfortunately, even grow with time (i.e., moral residue crescendo), with devastating long-term consequences. Two of the most serious problems are (1) becoming morally numb to ethically challenging situations and (2) developing clinician burnout and potentially leaving the profession. Such serious risks remind us that moral distress is not benign; it behooves organizations to do what they can to prevent and snuff out moral distress as part of their strategic retention plan for employees.

**Moral Courage**

Although courage can be defined in many ways, an outstanding description as it relates to the ICU is the old adage that “moral courage entails feeling fear and acting anyway.” It’s not always easy to summon up the moral courage to act on one’s beliefs. We would like to focus on some cognitive strategies to help improve and strengthen one’s abilities to use moral courage to solve morally distressing problems.
Examples include cognitive reframing, whereby a person learns to stop negative thoughts and substitute more positive self-talk; self-soothing, whereby one takes steps to quiet oneself while facing a complicated situation; recognition of professional obligation; and developing risk tolerance. Having good mentorship and role models can help strengthen self-confidence and make people less risk-averse. It’s a good idea to talk to colleagues who have less emotional attachment to a given situation; doing so can enhance confidence and decrease risk aversion. Another skill involves being an excellent communicator, specifically with regard to the techniques of assertiveness and negotiation. One of our favorite quotations is, “Moral courage is a means to triumph over fear with practical action.”

Conclusion

As we’ve emphasized in previous editorials, our profession is a noble one. Nevertheless, at some point in our daily practice most of us will encounter circumstances that bring about moral distress. We’ve tried to show that moral distress happens, that none of us are alone, and that there are numerous structured interventions that can help minimize the negative impact of these situations. Simply being able to recognize that our vague symptoms of anxiety, anger, and confusion may be related to moral distress can help to alleviate and even improve our personal outlook. When the members of the ICU team work together in a unified way toward developing our collective “moral courage muscle,” we all become better advocates for our profession and for our patients.

Acknowledgements
RS would like to thank Thomas Smith, RN, DNP, NEA-BC, Chief Nursing Officer and Senior Vice President, Maimonides Medical Center, for his support and inspiration in writing this article.

References

To purchase electronic or print reprints, contact American Association of Critical-Care Nurses, 101 Columbia, Aliso Viejo, CA 92656. Phone, (800) 899-1712 or (949) 362-2050 (ext 532); fax, (949) 362-2049; e-mail, reprints@aacn.org.

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**Clinical Pearls**

Mary Jo Grap, RN, PhD, ACNP, Section Editor

**Clinical Pearls** is designed to help implement evidence-based care at the bedside by summarizing some of the most clinically useful material from select articles in each issue. Readers are encouraged to photocopy this ready-to-post page and share it with colleagues. Please be advised, however, that any substantive change in patient care protocols should be carefully reviewed and approved by the policy-setting authorities at your institution.

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### Measuring Nurses’ Cognitive Workload

Nursing productivity has been studied for years, but no current tools capture the cognitive workload of nursing care. Connor and colleagues developed the Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool to include the multiple dimensions of pediatric critical care nursing in quantifying nursing workload and resource allocation. After using the CAMEO with 75 pediatric cardiac intensive care unit patients, they found the following:

- Fourteen domains of care adequately represented direct and indirect cognitive processes associated with nursing care.
- Five classification groups supported interpretation of the tool’s complexity rating scores, with 80% of the sample in class III or IV.

The CAMEO can be used to inform staffing needs, but more importantly, it considers cognitive workload and can offer guidance for staff synergy, educational innovations in theory, and clinical skills necessary for increasingly complex patient care.

—Rhonda Board, RN, PhD, CCRN

### Clinical Indicators for Endotracheal Suctioning in Adults

What is the best method to determine the need for suctioning? Sole and colleagues carried out a descriptive, comparative study to determine which assessments were best indicators for endotracheal suctioning. They found the following:

- Lung auscultation, a common practice, is not a valid cue to indicate need for endotracheal suctioning because it indicates secretions below the trachea and carina. Lung sounds were the same before and after suctioning.
- Coarse expiratory crackles over the trachea, and/or a sawtooth pattern on the flow-time scalar or flow volume loop waveform, are recommended best practice indicators for endotracheal suctioning.
- Physiological changes such as high pressure alarms, desaturation, increased peak inspiratory pressure, coughing, and visible secretions should also be assessed.

Six previous studies and guidelines from the American Association of Respiratory Care were also carefully reviewed.

—Bill Donnelly, RN, PMBA, CCRN

### Occipital Pressure Ulcers in Infants and Children

Most research on pressure ulcers has focused on adult and geriatric populations and risk assessment tools. Manning and colleagues conducted a study that is the first to assess factors for the development of occipital pressure ulcers in pediatric patients. They found the following:

- Most often, occipital pressure ulcers were identified several weeks into patients’ hospitalization.
- High-risk patients were those who required mechanical ventilation, sedation, vasoactive medications, and had vascular access devices restricting head movement.
- A total of 42% of the population was described as agitated on the State Behavioral Scale.

A knowledge of risk factors can prospectively identify infants and children at risk and allow implementation of nursing interventions to prevent these ulcers.

—Rochelle Armola, RN, MSN, CCRN

### Skype and FaceTime For Parent Updates in Neonatal Intensive Care Units

The inclusion of patients and families in decision making is a hallmark of family-centered care. But what if the family is unable to visit the hospital? Epstein and colleagues used real-time videoconferencing via Skype and FaceTime to include family members of critically ill neonates in care discussions. The following should be considered:

- Patients and families should be aware that Skype and FaceTime are not compliant with the Health Insurance Portability and Accountability Act (HIPPA); therefore, privacy cannot be guaranteed.
- Measures to protect privacy include having the family make the initial phone call, providers using a password-protected device, and educating providers on camera placement and voice volume.

Although the sample size in this study is small, it provides evidence that daily videoconferencing updates may improve parents’ understanding of their infants’ condition.

—Kimberly Whiteman, RN, DNP

### Severity Scoring Systems and Cardiac Surgery Patients

Severity scoring systems for the critically ill may be unreliable for cardiac surgery patients due to the pathophysiologic consequences of cardiopulmonary bypass, which influences the variables usually scored. Exarchopoulos and colleagues tested these various scoring systems for morbidity and mortality in this patient population: Cardiac Surgery Score (CASUS), Acute Physiology and Chronic Health Evaluation (APACHE) II, Simplified Acute Physiology Score (SAPS) II, Sequential Organ Failure Assessment (SOFA), and the European System for Cardiac Operative Risk Evaluation (EuroSCORE) II. They found the following:

- All scoring systems showed acceptable performance.
- CASUS demonstrated superiority for benchmarking and risk stratification in cardiac surgery patients. CASUS was also superior for predicting mortality, with EuroSCORE II following.
- SOFA was the least predictive. Although SOFA had a strong association with in-hospital morbidity, CASUS performed better.

Mortality was defined as death within 30 days after surgery, and morbidity variables included duration of mechanical ventilation, length of stay, readmission, and reintubation.

—Alethea Sment, RN, BSN, CCRN-CSC

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DEFINING THE MEDICAL INTENSIVE CARE UNIT IN THE WORDS OF PATIENTS AND THEIR FAMILY MEMBERS: A FREELISTING ANALYSIS

By Catherine L. Auriemma, MD, Sarah M. Lyon, MD, Lauren E. Strelec, BS, Saida Kent, BS, Frances K. Barg, PhD, and Scott D. Halpern, MD, PhD

**Background** No validated conceptual framework exists for understanding the outcomes of patient- and family-centered care in critical care.

**Objective** To explore the meaning of intensive care unit among patients and their families by using freelisting.

**Methods** The phrase intensive care unit was used to prompt freelisting among intensive care unit patients and patients’ family members. Freelisting is an anthropological technique in which individuals define a domain by listing all words that come to mind in response to a topic. Salience scores, derived from the frequency with which a word was mentioned, the order in which it was mentioned, and the length of each list, were calculated and analyzed.

**Results** Among the 45 participants, many words were salient to both patients and patients’ family members. Words salient solely for patients included consciousness, getting better, noisy, and personal care. Words salient solely for family members included sadness, busy, professional, and hope. The words suffering, busy, and team were salient solely for family members of patients who lived, whereas sadness, professionals, and hope were salient solely for family members of patients who died. The words caring and death were salient for both groups.

**Conclusions** Intensive care unit patients and their families define intensive care unit by using words to describe sickness, caring, medical staff, emotional states, and physical qualities of the unit. The results validate the importance of these topics among patients and their families in the intensive care unit and illustrate the usefulness of freelisting in critical care research. (American Journal of Critical Care. 2015;24:e47-e55)

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doi: http://dx.doi.org/10.4037/ajcc2015717

COMMUNICATING WITH PATIENTS’ FAMILIES AND PHYSICIANS ABOUT PROGNOSIS AND GOALS OF CARE

By Michelle M. Milic, MD, Kathleen Puntillo, RN, PhD, Kathleen Turner, RN, BSN, Denah Joseph, MFT, Natalie Peters, RN, MSN, Rio Ryan, RN, MSN, Cathy Schuster, RN, BSN, Holly Winfree, RN, Jenica Cimino, BA, and Wendy G. Anderson, MD, MS

**Background** Integrating palliative care into intensive care requires active involvement of bedside nurses in discussions of patients’ prognosis and goals of care.

**Objective** To improve critical care nurses’ skills and confidence to engage in discussions with patients’ families and physicians about prognosis and goals of care by using a focused educational intervention.

**Methods** An 8-hour-long workshop was developed for critical care nurses. Key roles and skills of nurses in communication about prognosis and goals of care were defined. Participants practiced skills during facilitated role-plays. A reflection session addressed burnout, distress, and self-care. Participants completed surveys before, immediately after, and 3 months after their workshop, rating their confidence and skill in performing key tasks. Use of a participant focus group and open-response items in the surveys further elucidated the impact of the workshop.
Results  Between March 2011 and April 2013, a total of 82 critical care nurses completed a workshop. Compared with before the workshop, after the workshop, nurses reported greater skill and confidence for 14 survey items ($P<.001$), including assessing families’ understanding of prognosis and goals of care, addressing families’ emotional needs, and contributing to family meetings. Increases were sustained 3 months after the workshop.

Conclusion  Defining roles and providing opportunities for skills practice and reflection can enhance nurses’ confidence to engage in discussions about prognosis and goals of care. (American Journal of Critical Care. 2015;24:e56-e64)

CEREBRAL PERFUSION PRESSURE AND DELAYED CEREBRAL ISCHEMIA AFTER ANEURYSMAL SUBARACHNOID HEMORRHAGE

By Khalil M. Yousef, RN, PhD, Jeffrey R. Balzer, PhD, Catherine M. Bender, RN, PhD, Leslie A. Hoffman, RN, PhD, Samuel M. Poloyac, PhD, PharmD, Feifei Ye, PhD, and Paula R. Sherwood, RN, PhD, CNRN

Background  Whether delayed cerebral ischemia (DCI) mediates the relationship between Hunt and Hess grade and outcomes after aneurysmal subarachnoid hemorrhage remains unknown.

Objectives  To investigate the relationship between cerebral perfusion pressure, DCI, Hunt and Hess grade, and outcomes after aneurysmal subarachnoid hemorrhage.

Methods  DCI was defined as neurological deterioration due to impaired cerebral blood flow. Relationships between minimum cerebral perfusion pressure and onset and occurrence of DCI were tested by using logistic regression and the accelerated failure time model. The mediation effect of DCI on relationships between Hunt and Hess grade and outcomes was tested by using the bootstrap confidence interval. Outcomes at 3 and 12 months included mortality and neuropsychological, functional, and physical outcomes.

Results  DCI occurred in 211 patients (42%). About one-third of the patients had poor functional outcome at 3 (32%) and 12 (30%) months. Impaired neuropsychological outcome was observed in 33% of patients at 3 months and 17% at 12 months. For every increase of 10 mm Hg in cerebral perfusion pressure, odds for DCI increased by 2.78 (95% CI, 2.00-3.87). High perfusion pressure was associated with earlier onset of DCI ($P<.001$).

Conclusions  DCI does not mediate the relationship of Hunt and Hess grade to functional outcome or death. The relationship between cerebral perfusion pressure and DCI was most likely due to induced hypertension and hypervolemia. Clinical guidelines may need to include limits for induced hypertension. (American Journal of Critical Care. 2015;24:e65-e71)
Research at the bedside makes a difference for our patients, and also for our nurses. However, it is now time to broaden our focus from research on interventions or events at a narrow point in time to research that addresses care across the continuum. This continuum may start at the point of injury, such as the battlefield through en route care delivered during the 8000-mile journey home for our wounded warriors, or for critically ill patients as they move between the emergency department, operating room, and intensive care unit. This focus also requires researchers to consider “care within context,” that is, research- and evidence-based practice tailored to the unique conditions of the care environment. Beyond conducting research and developing new knowledge is the challenge of translating evidence into practice. A culture of inquiry is a critical element in the successful translation of evidence into practice. In a culture of inquiry, nurses are encouraged to question and evaluate their practice, provide evidence-based care, and actively participate in and lead clinical inquiry. This article draws from a program of applied clinical research reflecting care across the continuum within both military and civilian health care settings and discusses how the application of these research findings and the advancement of a culture of inquiry make a difference for both patients and nurses. (American Journal of Critical Care. 2015;24:283-289)
Research at the bedside makes a difference for our patients, and also for our nurses. How can we continue to enhance the difference this research makes? As we look for strategies to optimize outcomes further, one strategy may be to broaden our research focus from studies on interventions or events at a narrow point in time to research that addresses care across the continuum. The continuum may start at the point of injury on the battlefield through the 8000-mile journey home for our wounded warriors, or for critically ill or injured patients who receive care in the emergency department, operating room, and intensive care unit (ICU). Another strategy is to advance a culture of inquiry. In a culture of inquiry, nurses are empowered to question and evaluate their practice, to provide evidence-based care, to actively participate and lead clinical inquiry, and to systematically translate evidence into practice. This article uses examples from a program of applied clinical research within both military and civilian health care settings that reflect care across the continuum, introduces 2 models that guide the translation of evidence into practice, and discusses how research at the bedside and the advancement of a culture of inquiry make a difference for both patients and nurses.

Care Across the Continuum

By necessity, research often focuses on a specific event at a specific point in time (eg, pressure ulcer prevention in the ICU). However, as we think about advancing care, a broader research focus that reflects care across the continuum is essential. Care across the continuum is important for military health care. A critically injured combat casualty receives care at a minimum of 4 hospitals and undergoes at least 4 transports (ranging from 15 minutes on a helicopter to 10 to 12 hours on a critical care air transport flight from Germany to the United States) during the rapid evacuation from the battlefield and along the continuum of care back to the United States. To optimize care and outcomes under these dynamic conditions, research must address care not only at a specific point in the continuum of care (eg, at a field hospital), but also care provided as patients move across the various settings in the care continuum. As an example of research across the continuum, a series of studies were completed to describe en route pain and pain management strategies for military patients undergoing aeromedical evacuation from the war zone to Germany. One finding was that the most severe pain occurred during transport from the ground facility to the aircraft. This finding indicates the need for a solution to en route pain management that begins during the preflight phase of care and extends through transport, while taking into consideration that 10 to 30 patients may be transported simultaneously.

The principle of care across the continuum also applies to civilian health care research. In developing this paper, American Association of Critical-Care Nurses (AACN) journals from the past 5 years were reviewed for research reflecting care across the continuum. A few studies focused on care coordination, transitions, and handoff communication. However, no research was found that explicitly investigated problems extending across multiple locations where critical care is provided (eg, pressure ulcer prevention in the emergency department, ICU, operating room). To make a difference in patient care and outcomes, we need to identify and study collaborative solutions across the continuum of care.

Care Within Context

When studying care across the continuum, it is also important to consider the care environment (ie, care within context). For my research, the care environment may be the austere environment of a battlefield hospital, during military aeromedical evacuation, or in a critical care unit in the United States. To identify research questions specific to care across the continuum and within context, my research partner, Dr Joe Schmelz, and I asked 5 questions:

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1. What do we do on a day-to-day basis that we will also do in the deployed setting?
2. What is unique about the deployed setting?
3. Who are our patients?
4. How does the deployed environment affect the patients and the care provided?
5. Where is the nursing in the question?

My primary research and practice focus has always been on hemodynamic monitoring. This work ranges from the accurate performance of hemodynamic monitoring, integration of hemodynamic data into care, and answering the age-old question: “which do you believe—the a-line or the cuff?”11-18 One aspect of ensuring accuracy in invasive pressure monitoring is removing microbubbles from the pressure system.11 As an example of care within context, the removal of microbubbles takes on greater importance in aeromedical evacuation, as gas expands at altitude (Boyle’s law). My colleagues Lt Col Karen Evers, USAF (ret), and Dr Susan Woods, and I studied the effects of microbubble expansion at altitude on the dynamic response characteristics of the system, conducting research both in an altitude chamber at 10000 feet (3000 m) and in the back of a military cargo aircraft used for aeromedical evacuation. As expected, microbubble expansion at altitude adversely affects the dynamic response, such that the system would be unacceptable for monitoring during this critical phase of care. We then validated a protocol that included an easy, systematic process to minimize microbubbles in the system.9 The new protocol optimized the pressure monitoring system both on the ground and at altitude.19

These same 5 questions can be used to identify research specific to your practice area by simply exchanging the word “deployed” with the definition of your care setting. As discussed next, these questions helped us to develop interventions for use in the ICU and operating room to decrease pressure ulcers in high-risk cardiac patients.

Use of Frameworks to Guide the Translation of Evidence into Practice

Beyond the challenges of conducting research and creating new knowledge is the challenge of evidence translation. Nieva’s Knowledge Transfer Framework (Figure 1),20 is a framework that was useful in identifying the steps involved with translation of research and strategies to prevent hypothermia.10

A Need for New Knowledge: “There Will Be No Hypothermia in Theater”

In early 2002, the military research community was challenged by the pronouncement: “There will be no more hypothermia in theater.” As outlined in Nieva’s framework, the first step is the creation of knowledge. In response to this challenge, our team of Air Force nurse scientists, Lt Col Joe Schmelz, Col Don Johnson, Lt Col Marla De Jong, Lt Col Karen Evers, and I, set out to identify the most effective strategies to prevent hypothermia in combat casualties under the austere conditions found in theater (ie, an area where military events occur, such as Iraq or Afghanistan). We were further challenged by the stipulation that whatever solution we came up with had to weigh less than 7 lb (3 kg), be portable, use minimal or no electricity, and pass safety testing for use in both helicopters and fixed-wing aircraft. We completed a series of studies evaluating commercial off-the-shelf products in a model of severe hemorrhagic shock under ambient conditions that mimicked evacuation from the battlefield on rotary and fixed-wing aircraft. The solution we identified, which included a baffled reflective blanket, a head cover, and a heating pack, reflects the principle that to prevent hypothermia in patients with severe

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Figure 1 Knowledge Transfer Framework from the Agency for Healthcare Research and Quality.
Reprinted from Nieva et al.20
hemorrhage one must not only prevent heat loss, but also give heat back to the body.21,22 As scientists, we met our mandate by creating new knowledge and identifying a technical solution to hypothermia in the field. However, to prevent hypothermia, the creation of new knowledge was only the first step.

The next phase of translation is to diffuse and disseminate. The Joint Theater Trauma System created a hypothermia prevention clinical practice guideline (CPG), which was disseminated throughout the theater. We were proud that the hypothermia CPG23 included recommendations based on our research and outlined care and monitoring requirements for each phase of the care continuum.

The final steps of translation can be characterized by strategies to promote sustainability or, more specifically, strategies to facilitate adoption, uptake, and institutionalization. Institutionalization refers to the integration of the innovation into the organization through actions such a policy and as evidenced by its routine use in practice. In addition to emphasizing the CPG, hypothermia prevention kits consisting of the blanket, head cover, and warming pad were placed in every military medical unit. Compliance with the CPG and the incidence of hypothermia on admission were monitored, and all cases of hypothermia were examined as a part of process improvement. In the book, Better: A Surgeon’s Notes on Performance, Gawande24(p56) discussed how the US military’s commitment to “make a science of performance, to investigate and improve how well they use the knowledge and technologies they already have at hand” revolutionized the treatment of combat casualties. Gawande suggested that it is not the creation of new knowledge or technologies, but systems-level changes to ensure the use of existing knowledge and technologies, and vigilance over performance, that may be the critical factors in improving outcomes. Vigilance over performance answers the critical question: are we making a difference? In 2006, the Joint Theater Trauma System and the Joint Theater Trauma Registry were created to standardize and improve care across the theater and to monitor care processes and outcomes. Trauma nurse coordinators (ie, military nurses who collected injury demographics, care, and outcomes for both military and civilian casualties) were placed at military hospitals in Iraq and Afghanistan.25,26 Among the trauma nurse coordinators’ many responsibilities, they recorded critical information, including body temperature at admission and use of hypothermia-prevention strategies for all trauma patients.

We needed evidence-based resources that reflected both medical and nursing care.

Did we make a difference? Before implementation of the hypothermia CPG, 7% to 10% of combat casualties were hypothermic on admission, in contrast to 1% to 4% after CPG implementation,27,28 which was in contrast to a 13% to 43% incidence of hypothermia for severely injured patients admitted to US trauma centers.29,30 More importantly, there was a system-wide awareness of the issue, with everyone, from medics to chaplains, understanding the importance of hypothermia prevention.

On a broader note, hypothermia prevention is only one aspect of combat casualty care. In discussion with nurses across the military, it became apparent that the nurses were aware of the CPGs, but they could not consistently recall the content. One challenge was that the CPGs were medically focused. We needed evidence-based resources that reflected both medical and nursing care. I received a grant from the TriService Nursing Research Program (TSNRP), to create the Battlefield and Disaster Nursing Pocket Guide31 to bring together evidence about care under operational conditions. The pocket guide was designed to be carried in a uniform pocket in order to put evidence on unique types of care (eg, hypothermia prevention, care of bomb-blast victim) directly into the hands of the nurses. With grants from TSNRP, we have distributed 22,000 copies of the guide to deploying nurses and medics from all 3 services. But similar to the CPGs, the pocket guide reflects only dissemination.

Our challenge is to ensure that our military nurses remain ready to provide this evidence-based care. Under a study funded by TSNRP, a systematic literature review was completed to create a list of operational nursing competencies. We revised and validated the list through expert panels and a survey of deployed nurses. With expert consultation from Dr JoAnn Grif Alspach, and with the pocket guide as a source document, we created an organizing framework, outlining the required competencies and training and performance standards. As a scientist, I could have ended the research by simply publishing these results. However, to make a difference, we needed to institutionalize the competency lists and put them in place education, training, and tracking requirements to support their implementation. Although this process has taken several years, in January 2015, the board of directors of the Air Force Nurse Corps approved a policy establishing the competency lists as the standard for readiness education and training for the more than 5300 Air Force active duty, guard, and reserve nurses. Will this program make a difference? We hope that it does, by enhancing evidence-based operational care and ensuring that we retain the hard-learned lessons of the past 14 years, as we continue to provide world-class care to our wounded warriors.
In practice, the need for evidence translation often begins with a clinical event. Another translation framework, the Roadmap for Participatory Research (Figure 2),32 which has direct relevance to clinical practice, starts with a “call to action,” a practice issue for which there may or may not be an evidence-based solution. At the University of Washington Medical Center (UWMC), our “call to action” was an increased incidence of occipital pressure ulcers in our high-risk cardiothoracic ICU patients. During hospitalization, critically ill patients often move between multiple diagnostic and care areas; thus, the solution to preventing pressure ulcers for these patients needed to reflect care across the continuum. We conducted a literature review but did not find any strategies to address this issue. Teams of nurses from the operating room and ICU stepped forward to address this issue. Through a systematic process, they identified pressure-redistributing strategies (eg, gel and foam occipital pads for the operating room and a “waffle”-type cushion for the ICU). The operating room team garnered support from anesthesia providers by presenting data outlining the issue and recommended solutions. The ICU and operating room teams implemented a collaborative plan to enhance communication, ensure that all preventive strategies were used when high-risk patients moved across the care continuum, and monitor and assess patients in collaboration with our wound clinical nurse specialists.

Did we make a difference? Yes, for both our patients and our nurses. At the time of our call to action, there were 8 occipital decubitus ulcers within a year. Since implementation of this initiative in 2011, only 1 occipital decubitus ulcer (from a hair braid) has been found among these high-risk patients. Additionally, the nurses who were involved have enhanced their ability to address clinical questions systematically by using research methods. They are champions for sustainment and are taking on new initiatives. Further, they have confidently presented their work to hospital leaders, at local and national forums, and they are currently writing a manuscript summarizing their work.

Advancing a Culture of Inquiry

At UWMC, a core construct of our professional practice model is a culture of inquiry (see Table). Central to the culture is clinical inquiry. Our definition of clinical inquiry expands upon the AACN definition33 and emphasizes creation of new knowledge and the systematic use of evidence at the bedside. Underpinning this culture of inquiry are several assumptions. First, a culture of inquiry is inextricably woven through our patient/family care and our professional practice. As such, we do not have a separate research council, rather a culture of inquiry...
Characteristics

- Culture of inquiry: The shared expectations, goals, and practices (including structures and processes) that support and advance clinical inquiry throughout the organization.
- Clinical inquiry: The ongoing and iterative process of questioning and evaluating practice and providing informed practice; the creation of practice change through research, evidence-based practice (including research utilization), and experiential learning.

Assumptions

- Inextricably woven through patient/family care and professional practice
- Requires that all nurses in the organization have a leadership role
- Recognizes and supports the various uses of research/evidence (instrumental, conceptual, symbolic)

Finally, underlining the advancement of a culture of inquiry is recognition of the various uses of research, or more broadly—evidence. In 1985, Stetler suggested that nursing research utilization is instrumental, conceptual, and symbolic. The instrumental (or concrete) use of evidence to develop protocols and policy, and ultimately to improve outcomes, is a vital aspect of evidence translation. However, within a culture of inquiry, more subtle uses of evidence are equally important. The conceptual use of evidence results in new insights or changes in the way an individual thinks about a topic, and symbolic use reflects use of evidence to support an opinion or to influence the views of others.

The recognition of various uses of evidence as a strategy to advance a culture of inquiry is embedded in talks I present at AACN’s National Teaching Institute on “Critical Care Studies You Should Know About.” Rather than summarizing research studies, this presentation uses studies as a starting point for a conversation about becoming a smart consumer of evidence. Underpinning the presentation are the 3 aspects of evidence use. The goal of the talk to inspire active engagement in care through the development of knowledge of a specific topic (conceptual use) and confidence in the ability to use research directly at the bedside and in policy development (symbolic and instrumental use), and to communicate effectively and advocate for evidence-based recommendations (symbolic use).

Finally, a culture of inquiry can be strengthened by academic-service partnerships. My colleagues from the University of Washington School of Nursing, Dr Joanne Whitney and Dr Karen Thomas, and I have appointments at Harborview Medical Center, Seattle Children’s Hospital, and UWMC, respectively. Our roles focus on advancing the culture of inquiry through our work with direct care and advanced practice nurses and administrators in support of 3 goals:

1. Infusing a culture of inquiry through all patient care activities
2. Building capacity for nurses to actively participate and lead in clinical inquiry
3. Creating structures/processes to facilitate
dissemination, adoption, implementation, and institutionalization and evaluation of evidence-based care

Are we making a difference? Each year in Seattle, more than 250 clinical nurses come together at the Seattle Nursing Research Consortium conference (http://seattlenursingresearch.org) to learn about and present their research and evidence-based practice. The support of the health care organizations and the passion exemplified by these nurses to advance their care are extraordinary. Many of these nurses go on to present at national forums, such as the National Teaching Institute, to publish, to return for advanced academic preparation, and then to return to mentor others. Yes, I think research at the bedside makes a difference.

FINANCIAL DISCLOSURES
None reported.

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REFERENCES
34. Porter-O’Grady T. Leadership at all levels. Sudbury, MA: Jones & Bartlett; 2009.

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Testing the Feasibility of Skype and Facetime Updates with Parents in the Neonatal Intensive Care Unit

By Elizabeth Gingell Epstein, RN, PhD, Jessica Sherman, RN, FNP-BC, Amy Blackman, BSN, CCRC, and Robert A. Sinkin, MD, MPH

Background Effective provider-parent relationships are essential during critical illness when treatment decisions are complex, the environment is crowded and unfamiliar, and outcomes are uncertain.

Objectives To evaluate the feasibility of daily Skype or FaceTime updates with parents of patients in the neonatal intensive care unit (NICU) and to assess the intervention’s potential for improving parent-provider relationships.

Methods A pre/post mixed-methods approach was used. NICU parent participants received daily Skype or FaceTime updates for 5 days and completed demographic and feasibility surveys. Parents also completed Penticuff’s Parents’ Understanding survey before and after the intervention. Nurses and physicians completed feasibility surveys after each update.

Results Twenty-six parents were enrolled and 15 completed the study. More than 90% of providers and parents perceived the intervention to be reliable and easy to use, and about 80% of parents and providers rated video and audio quality as either excellent or good. Frozen screens and missed updates due to scheduling problems were challenges. Two of the 4 subscores on the Parents’ Understanding survey improved significantly. Qualitative data favor the intervention as meaningful for parents.

Conclusions Real-time videoconferencing via Skype or FaceTime is feasible for providing updates for parents when they cannot be present in the NICU and can be used to include parents in bedside rounds. Videoconferencing updates may improve relationships between parents and the health care team. (American Journal of Critical Care. 2015;24:290-296)
Family-centered care (FCC) has been recognized as an important approach to health care quality for decades.\textsuperscript{1-4} In pediatrics, the focus of FCC is to build trusting relationships between parents and the health care team by using 9 core principles (eg, inclusion of families in decisions about treatment and care, flexibility with rules or practices in order to help families with particular needs or values, and sharing honest information on an ongoing basis in ways that families find useful).\textsuperscript{3,5,6} Although FCC is a vital component in providing high-quality care, implementation of the FCC model in clinical practice presents a challenge to health care professionals. FCC requires broad-reaching buy-in from all members of the health care team and the health care institution that may require changes in institutional design and policy. The multiconceptual nature (communication, respect, collaboration, and empowerment), consequent lack of accurate measures, and lack of direct financial reimbursement for FCC-related activities\textsuperscript{7} are additional barriers.\textsuperscript{3-8} Despite these challenges, family inclusion in the whole of pediatric patient care is a worthy goal, and an attainable one with multiprofessional and institutional commitment.

There is some concern that the FCC model promotes information sharing to the point that the burden of decision making is placed squarely on the shoulders of family members in the name of respect for autonomy.\textsuperscript{9,10} However, as noted by Kon et al,\textsuperscript{11} family members’ desires and abilities to be involved in decision making vary greatly along a “shared decision-making continuum” that ranges from physician-driven to patient/family-driven decision making. If applied as originally intended, FCC allows providers and patients’ families to find the most appropriate balance of decisional authority by using an individualized and collaborative approach to care and planning. To apply FCC in this way requires, at its root, an effective relationship between health care providers and patients’ families.

Recent studies suggest that building effective provider-parent relationships improves parents’ well-being, honest communication, and collaborative decision making.\textsuperscript{12-15} Parents of hospitalized children desire to see familiar faces, be provided with honest information, be included as part of the team, and trust what is being communicated.\textsuperscript{10,16-20} Inconsistent caregivers, poor communication, and mistrust can contribute to conflict between providers and patients’ families and to regret.\textsuperscript{18,21-24} However, provider continuity is unrealistic in intensive care settings because of the involvement of multiple professions and the 24/7 nature of the work. Good relationships between providers and patients’ parents are essential during critical illness, when treatment decisions are complex, the environment is chaotic and unfamiliar, and outcomes are uncertain. Hence, some rethinking about how to build relationships between providers and patients’ parents is necessary, given the multiple shifts, rotations, and specialty services involved in care of patients in the neonatal intensive care unit (NICU).

Internet technologies may help strengthen relationships between patients’ parents and health care providers within the environmental constraints of the unit. Such technologies are increasingly used as interventions to address health problems such as self-management of chronic disease, counseling children with traumatic brain injury, and binge eating among teens.\textsuperscript{25-27} In the NICU, several webcam programs are currently available, such as NICView\textsuperscript{28} and Angel Eye at the University of Arkansas.\textsuperscript{29,30} Another program (BabyCareLink) at the Beth Israel Deaconess Medical Center allows parents to view their infant and also provides informational and emotional support by using resources such as an online library and links to external resources.\textsuperscript{31} Although these programs have demonstrated benefits, none of these programs offers the ability to interact in

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About the Authors

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real time nor are the programs designed to promote or strengthen FCC, promote communication, or support trusting relationships. Further, these programs can be costly and require sophisticated software that may not be available in health care organizations without the resources to invest in such a system.

Publicly available systems such as Skype and FaceTime are alternatives to currently available technologies that allow real-time interaction and promotion of relationship building. These programs are free, widely accessible, and easy to use but are not compliant with the Health Insurance Portability and Accountability Act (HIPAA). Few studies have tested their acceptability in health care settings.32-34 We sought to determine whether a real-time videoconferencing intervention using Skype and FaceTime would be an acceptable form of communication between parents’ parents and members of the health care team, despite the lack of HIPAA compliance. Such an intervention would provide opportunities for parents not only to see their infants but also to see and converse with those caring for their child, thus promoting both parent-infant and parent-provider relationships.

The primary purpose of this study was to evaluate the acceptability and feasibility of using daily Skype or FaceTime updates for parents by measuring views of patients’ parents and health care providers on ease of use, reliability of connection, video quality, scheduling, content of daily updates, and overall satisfaction with the intervention. A secondary aim was to assess the intervention’s potential for improving parent-provider relationships.

Methods

This study used a pre/post mixed-methods approach and was approved by the institutional review board, and all participants provided informed consent.

Site and Sample

Parents were recruited from a 45-bed NICU at the University of Virginia Health System. This center serves as a regional referral center, and approximately 50% of NICU admissions are from counties outside the immediate vicinity. Parents were eligible to participate if they were more than 15 years old, spoke English, had a home computer or cell phone with Internet access, and if their infant was expected to stay in the NICU for at least 7 days beyond the day of recruitment.

Intervention

At the outset, we consulted expert members of the telemedicine department regarding the use of non–HIPAA-compliant technologies with parents. Their guidance led to a careful crafting of the consent form and enrollment procedures. All parents enrolled in the study were informed that neither Skype nor FaceTime are HIPAA compliant and that their privacy, therefore, could not be guaranteed. Additionally, in-service training for nurses and physicians emphasized the importance of confidentiality with regard to camera placement and voice volume.

The intervention provided parents with brief videoconferencing (Skype or FaceTime) updates from the bedside nurse or treating nurse practitioner or physician once daily for 5 days. Currently, parents receive updates by telephone at their convenience or as needed. The content of the updates was similar to what would be provided by phone (feedings, events of the day, general condition, answer parents’ questions) and were about 3 to 10 minutes in length. Updates were not scripted and no formal protocol was used. Providers used a dedicated password-protected iPad (Apple Corp) for updates. Portable cameras were lent to parents whose computer did not have a camera installed so that providers and parents could see each other. The cameras were returned to the study team at the end of the 5-day intervention.

Instruments

Feasibility surveys were developed for parents and providers (parent survey, see Figure). Parents’ demographic data (relationship to infant, race, education, employment) and medical record data (birth weight, gestational age, age on day of enrollment in study, sex, and acuity measures such as mechanical ventilation) were gathered by using surveys derived by the principal investigator. A postintervention open-ended survey invited parents to provide more detailed information about their experience with

Figure Neonatal intensive care unit’s Skype/FaceTime updates parent feasibility survey.
Skype or FaceTime, the content of their updates, and any further comments they had about the intervention. The Parents’ Understanding of Their Baby’s Care and Outcomes in the NICU survey (henceforth called the Parents’ Understanding survey) was completed before and after the intervention.

This survey is a 45-item Likert-style instrument with 4 subsections that is used to assess parents’ broad views of having an infant in the NICU (e.g., “I feel fully informed about my baby’s condition and prognosis”), specific parent experiences (e.g., “In the last week, how often did you give suggestions about your baby’s care to the nurses?”), problems encountered by premature infants (e.g., breathing problems, jaundice, weight gain), the degree to which the parent worried about these problems, and concerns about problems after discharge. Scores for each section are a simple sum of responses within that section, and the total score is the sum of all subscores. A previous study suggested good reliability for all sections (Cronbach α, 0.62-0.96).

Procedure and Measures
Before enrollment, all aspects of the study were described to potential parent participants, including the use of non-HIPAA-compliant videoconferencing technology and the resultant potential for breach of privacy. Upon providing written informed consent, parents completed a demographic questionnaire, a brief open-ended survey, and the Parents’ Understanding survey. When necessary, parents were given instructions on how to download and use Skype or FaceTime to interface with NICU staff. Each day, prior to their scheduled update, parents called the bedside nurse to arrange an exact time for the update. Parents initiated each call in order to ensure privacy. Parent participants were instructed that others (e.g., grandparents, siblings) were welcome to watch, but they (the parent) must be present.

Providers were instructed to have the camera initially on them so that they could introduce themselves to the parent, giving the parent and provider an opportunity to see each other face-to-face. Following this introduction, the camera could be shifted to focus on the infant for the remainder of the update. At the end of each update, the provider completed a feasibility survey. In addition, parents completed a feasibility survey, a brief open-ended survey, and the Parents’ Understanding survey after the 5-day intervention had been completed.

Data Analysis
Quantitative data were analyzed by using SPSS v21 (SPSS Inc) after being cleaned and verified. Qualitative data were analyzed by using content analysis. The primary aim, to determine whether real-time videoconferencing is feasible in the NICU, was evaluated by using both quantitative (feasibility surveys) and qualitative data. The exploratory aim was evaluated with descriptive statistics of the Parents’ Understanding survey and repeated-measures t tests to determine whether the parent’s understanding of their infant’s condition changed over the time of the intervention.

Results
During the study period, 26 parents of 25 infants were enrolled. Most (80%) of the parents were mothers, 80% were white (12% African American, 8% other), and none were of Hispanic origin. Most infants were premature (22 of 25). Two infants born at term had congenital defects and 1 had sepsis. Although severity of illness was not directly measured, 9 were intubated and 2 were receiving vasopressor support at the time of the study (Table 1).

Parents who completed the study and those who did not did not differ significantly on the basis of education, race, relationship (mother/father), infant’s age (day of life on the day of enrollment), or presurvey scores.

Feasibility
Nineteen parents of 19 infants completed at least 2 Skype or FaceTime updates, and 15 completed all the instruments (before and after the intervention), a 57% completion rate. Most (5) of the 7 parents who did not complete all instruments were enrolled early in the study period, when problems with wireless connection reliability, scheduling, and plans for follow-up with parents were encountered. Since resolving these problems, only 2 of 14 parents have not returned their postsurveys.

Several parents declined to enroll in the study for stated reasons of lack of interest, concerns about privacy (1 parent), lack of perceived need, lack of Internet access, and “too much to think about.”

Provider feasibility surveys (n = 37) and parent feasibility surveys (n = 15) suggest that using Skype/FaceTime is an acceptable communication modality in the NICU. Most providers (94%) and all parents

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Infants’ characteristics (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristic</strong></td>
<td><strong>Value</strong></td>
</tr>
<tr>
<td>Female sex, %</td>
<td>68 (n = 17)</td>
</tr>
<tr>
<td>Birth weight, mean (SD), range, g</td>
<td>1563 (772), 510-3354</td>
</tr>
<tr>
<td>Gestational age, mean (SD), range, weeks</td>
<td>31 (4), 25-39</td>
</tr>
<tr>
<td>Age on day of enrollment, mean (SD), range, days</td>
<td>24 (25), 1-85</td>
</tr>
<tr>
<td>Mechanical ventilation during study, %</td>
<td>36 (n = 9)</td>
</tr>
</tbody>
</table>
rated the ease of updates as either excellent or good. Video and audio qualities were rated as excellent or good by 78% of parents and 88% of providers. Several responses of fair or poor video quality were due to frozen frames during updates. Overall, more than 90% of providers and parents perceived the intervention to be reliable for updates in the NICU.

Qualitative data from parents revealed that parents appreciated the updates and believed that they should be continued throughout the NICU stay. Three parents noted that Skype/Facetime updates might not be necessary or wanted by some parents, but that for many, this technology might be very helpful on a daily basis. Unique, positive comments were made by 3 parents. One mother noted that the intervention allowed her grandfather to see his great-granddaughter for the first time the day before he (grandfather) died. Another parent stated that the intervention allowed the infant’s siblings, who had not been able to travel to the hospital, to see their new brother.

Finally, one couple (the husband had returned to work in their hometown about 2 hours away from the hospital while the wife stayed in a hotel near the hospital) appreciated the intervention so much that they bought a laptop to continue the updates themselves.

As with any intervention, there were challenges. Technological challenges included mid-update freezing of pictures. This problem was not typically remedied by ending the call and restarting the update. Frozen screens were encountered by 4 parents on at least 1 occasion. For 1 parent, the problem was encountered several days in a row, and no further attempts were made after the third day. The hospital’s information technology staff suggested that the problem was most likely due to the Internet at the parent’s home and not at the hospital and thus is a difficult problem to fix. The problem might be helped if the updates are done with the laptop in the same room as the wireless box. This remedy has been suggested to parents recently, but there have been too few instances of the problem to report whether this solution is acceptable. Other technology-related challenges included parents not being able to download and use Skype for free on their cellphones.

Procedural challenges included missed opportunities for enrollment and lack of staff familiarity with the protocol or with Skype or FaceTime. Enrollment was improved with a research assistant and identification of 2 nursing staff “champions” as well as improved team/staff coordination. The champions are trained to identify potential parent participants, to enroll parents, to monitor the progress of the updates for parents, and to troubleshoot when necessary. The research assistant enrolled parents and monitored the study on a broader scale and collected presurvey and postsurvey data. Familiarity with the study protocol and with the technology itself has improved over time with continued in-service training, NICU newsletter updates, suggestions from staff about how to improve update scheduling, and support from the NICU administration.

### Parents’ Understanding

Analysis of the Parents’ Understanding surveys before and after the intervention revealed a clinically and statistically significant result, despite our small sample size (Table 2). Total scores were not significantly different before and after the intervention, but scores on the first and second subscales (parents’ impressions of information sharing, NICU care, relationships with their infants’ doctors and nurses, and satisfaction with care both overall and within the last week) were significantly different. Subscales 3 and 4 addressed parents’ concerns about their infants’ development. These scales were largely targeted for parents of premature infants. Although all but 1 of the infants whose parents

### Table 2

<table>
<thead>
<tr>
<th>Survey score, mean (SD), range</th>
<th>Before intervention</th>
<th>After intervention</th>
<th>Difference (paired t test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad views of having infant in neonatal intensive care unit (subscore 1)</td>
<td>63.2 (5.8), 51-76</td>
<td>69.1 (5.7), 58-79</td>
<td>t = 4.3, df = 12, P = .001</td>
</tr>
<tr>
<td>Specific parent experiences in last week (subscore 2)</td>
<td>27.6 (2.8), 22-35</td>
<td>29.5 (3.2), 26-35</td>
<td>t = 2.4, df = 12, P = .04</td>
</tr>
<tr>
<td>Presence of problems common to premature infants (subscore 3)</td>
<td>35.4 (13.2), 14-62</td>
<td>30.3 (13.4), 14-52</td>
<td>Not significant</td>
</tr>
<tr>
<td>Degree of parent worry about problems (subscore 4)</td>
<td>18.4 (7.2), 7-35</td>
<td>15.7 (5.9), 8-25</td>
<td>Not significant</td>
</tr>
<tr>
<td>Total</td>
<td>144.6 (16.6), 117-178</td>
<td>144.4 (18.3), 119-176</td>
<td>Not significant</td>
</tr>
</tbody>
</table>
completed the study were premature, scores on these scales did not change significantly.

Limitations

This study had several limitations. First, the sample size is small and homogeneous (largely white and well-educated). This intervention may not target parents who cannot afford or do not have access to the Internet. Before starting the study, we surveyed NICU parents (n = 27) regarding access to the Internet and found that 95% had access either via home computer or cellphone. Plans are in place to lend iPhones or iPads (Apple Corp) to parents for the duration of the study and to supply parents with temporary wi-fi cards in order to expand enrollment to include any NICU parent. A second limitation was that our method for tracking the number of updates (reliance on providers to record when updates were done) was inaccurate. An objective measure will be necessary in future studies in order to determine how often updates are actually done. Third, we did not formally track the rationales of parents who declined to participate, although the most common reasons given by parents informally were that parents did not have reliable access to the Internet or were present on the unit enough that an additional update was not needed. A better understanding of parents’ reasons for not participating is certainly necessary and worth consideration in future studies. Finally, with our small sample size, we were unable to discern differences in terms of feasibility, interest in enrollment, or usefulness of videoconference updates based on parents’ race, distance from the hospital, or severity of illness. Future studies are needed to flesh out these differences in order to ensure that interventions such as this reach the populations who can most benefit.

Discussion

This pilot study indicates that real-time videoconferencing using publicly accessible tools such as Skype and FaceTime are feasible and acceptable to both parents and providers. In designing the real-time videoconferencing intervention, we initially sought to target parents who lived a long distance from the hospital, as this comprises approximately 50% of our admissions annually. We quickly learned, however, that although many parents lived within easy driving distance of the hospital, they too wanted to participate in the intervention. Thus, study enrollment was broadened to include most parents in the NICU. This turned out to be an important feature of the study because many parents, including those who were able to visit daily, appreciated the opportunity to have an update when they could not be with their infant in the unit.

One recommendation for FCC has been family involvement in bedside rounds.\(^1,3^7\) Although there are certainly pros and cons regarding this,\(^3^6-4^1\) the logistical challenges are at least eliminated with the availability of real-time videoconferencing. It is no longer necessary for parents to be physically present in the unit in order to participate in rounds.

In a critical care setting like the NICU, strong trusting relationships between families and the health care team are key to providing high-quality appropriate care. Current research suggests that weakness in communication patterns between the health care team and patients’ families persists.\(^4^2-4^5\) This contributes to a lack of empowerment and confidence about readiness for discharge\(^4^6\) and provider-family conflict.\(^4^6,4^7\) FCC practices that promote consistent communication and purposeful interaction between all individuals involved in a patient’s care, such as daily updates with patients’ families via real-time video conferencing, may ultimately be useful in bridging current gaps in FCC. Although there is no substitute for in-person discussion, videoconference interventions may promote involvement of patients’ families in decision making and build effective relationships between patients’ families and the health care team that are essential to high-quality and appropriate care.

ACKNOWLEDGMENTS

The authors thank Dr Karen Rheuban, professor and director of the UVA Center for Telehealth, for her guidance in ensuring appropriate parent consent to use Skype and FaceTime for updates. We also thank Kamera Aulie, RN, and Sarah Clawson, RN, for serving as study champions.

FINANCIAL DISCLOSURES

This study was funded by a grant from the University of Virginia Children’s Hospital Faculty Grant-In-Aid program.

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SEE ALSO

For more about neonatal care, visit the Critical Care Nurse website, www.cconline.org, and read the article by Busse et al, “Parents’ Responses to Stress in the Neonatal Intensive Care Unit” (August 2013).

REFERENCES


45. SUPPORT A controlled trial to improve care for seriously ill hospitalized patients: the study to understand prognoses and preferences for outcomes and risks of treatments (SUPPORT). The SUPPORT Principal Investigators. JAMA. 1995;274:1591-1598.


50. SUPPORT A controlled trial to improve care for seriously ill hospitalized patients: the study to understand prognoses and preferences for outcomes and risks of treatments (SUPPORT). The SUPPORT Principal Investigators. JAMA. 1995;274:1591-1598.


Background Historically, nursing productivity has been measured in adult settings and based on time, intensity, and resource allocation.

Objective To develop a comprehensive measure of pediatric critical care nursing workload.

Methods An expert panel of pediatric critical care nurses used a modified Delphi method to identify 14 domains of nursing care with a number of corresponding care items in each domain. By consensus, they assigned each care item a cognitive complexity rating from 1 to 5. The panel next developed a classification system (classes I-V) to support interpretation of the patient's total score. The Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool was initiated with a cohort of 75 pediatric cardiac critical care patients to verify comprehensive capture of nursing care. Results of completed CAMEO tools were summarized by using descriptive statistics.

Results The cognitive workload across 14 domains of care was described, and each care item in the domain was scored. The range of CAMEO total scores was 25 to 230 (median, 124). For the initial cohort of patients, the cognitive complexity of care classifications were 13% as class I or II, 80% as class III or IV, and 7% as class V.

Conclusions The CAMEO tool was comprehensive in describing and quantifying the cognitive workload of pediatric critical care nurses. The CAMEO classification process informs staffing needs that support synergy between the needs of patients and their families and nurses’ knowledge and skill. Articulation of nursing care focused on informed clinical decision making is needed to justify the value of skilled nurses. (American Journal of Critical Care. 2015;24:297-308)
Nursing productivity has been measured to describe and quantify nursing workload, intensity, and resource allocation. These tools were mostly developed and tested in adult critical care settings in the 1970s and 1980s. Pediatric critical care requires an additional knowledge base and skill set to care for patients with varying developmental constraints plus congenital or acquired pediatric disorders. The current tools for measuring nursing workload are not inclusive of these multiple dimensions of pediatric critical care nursing. Therefore, we developed the Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool to address the cognitive workload of nursing care.

Review of Literature

In the past 40 years, researchers have attempted to measure nursing workload. An early tool linking nursing activities with patients’ acuity was the Therapeutic Intervention Scoring System (TISS). In 1974, Cullen et al. developed the TISS to estimate the severity of illness of adult patients in the intensive care unit by quantifying nursing interventions, support activities, and resources used for care. The TISS was subsequently revised to illustrate that time required for direct nursing activities correlated with an increase in nursing workload and depicted an accurate means of measuring nursing workload. One of the few efforts to adapt an existing workload tool to the pediatric critical care population was the modification of the TISS in the late 1970s. This modification was used to define use patterns, the relationship of severity of disease to survival, and the factors that determined patients’ outcome. Results were similar to those of the original TISS: nursing interventions trending upward as patients’ severity of illness trended upward.

None of the current nursing workload tools measures cognitive complexity, that invisible process of decision making during nursing care. Cognitive workload, defined by Ebright and colleagues, is the intellectual processing of information about patients that drives performance and decision making. Few researchers have focused on the cognitive aspect of clinical decision making related to patient/family-centered care. Researchers have described the broad range of thinking processes required in the acute care setting but have not articulated the magnitude of cognitive processes and the quantification of cognitive workload complexity. The purpose of this study was to describe and quantify the cognitive workload and complexity of contemporaneous pediatric critical care nursing.

Study Setting

A single cardiac intensive care unit (CICU) in Boston Children’s Hospital, a 395-bed, freestanding pediatric quaternary hospital, was the study site. The 29-bed CICU is dedicated to the management of infants, children, and adults with congenital or acquired heart disease. Patients are admitted either postoperatively from the cardiac operating room or for medical management of conditions such as cardiomyopathy, myocarditis, heart failure, and dysrhythmias. Many patients require support with multiple inotropic drugs to maintain hemodynamic stability or require mechanical assistance as a bridge to transplant. In addition, surgical procedures such as delayed sternal closure, chest exploration, and extracorporeal membrane oxygenation (ECMO) cardiopulmonary resuscitation are performed on the unit. The nurse to patient ratio is either 1 to 1 or 1 to 2, depending on patient care needs. Direct patient care is delivered solely by registered nurses. Nursing ancillary staff may assist in nursing procedures but are not independent care providers. Family-centered care is a key practice tenet, and patients’ families are encouraged to be active team members.

Phase I

After approval was granted by the institutional review board, an expert panel of 8 cardiovascular intensive care nurses was convened and charged with reviewing existing nursing workload tools.
almost all of which were developed for use in adult ICUs. This panel included experienced bedside nurses, a charge nurse, a clinical nurse specialist, and a clinical coordinator. A number of ICU tools were pilot tested, and none had a specificity of nursing care assessment, monitoring, and intervention that the panel deemed adequate. The tools also lacked description of care coordination, family support, and the indirect care management that is part of the bedside nursing role and is considered a component of cognitive workload.

Next the expert panel was charged to develop a list of all the interventions that represented their current practice. Using a modified Delphi technique, the expert panel participated in a series of 5 data query rounds. Rounds I to III focused on content development for the tool. The panel was encouraged to subtract and add to the proposed content to achieve a comprehensive list of items representing direct and indirect clinical interventions and nursing. Using the Nursing Interventions Classification language, the panel initially identified 19 domains of care to use for organizing their comprehensive list. Upon review, they noted redundancy, and after discussion, they reached consensus for 14 domains of care (Table 1).

The expert panel detailed how multiple cognitive processes were involved in the direct and indirect nursing interventions made throughout their shift. Clearly, nursing interventions are more than discrete entities. To capture the complexity of cognitive processes, line items corresponding to each intervention were identified. For example, if an order was written for intermittent intravenous furosemide, the nurse included as line items the critical thinking processes that accounted for giving the medication plus determining if the medication was the correct dose, the patient’s vital signs were acceptable, and the patient’s fluid balance and electrolyte values supported drug administration. By identifying all of these line items, a more complete representation of the cognitive processes involved in nursing assessment, intervention, and evaluation of a patient’s status is demonstrated. Many higher level nursing skills in addition to the technical skills are involved in the administration of an intermittent intravenous medication.

In rounds IV and V, the expert panel was asked to rate each line item individually on a scale from 1 to 5 in terms of cognitive workload complexity. The rated items were then presented to the expert panel for review. Members engaged in discussion of ratings, coming to consensus where differences existed and providing a final confirmation of each item. Cognitive workload complexity was defined as the intellectual processing of information about patients that drives decision making and performance. A cognitive complexity rating of 1 required the least cognitive thought process, whereas a rating of 5 required the most. For the monitoring domain, a complexity score was assigned on the basis of how often vital signs were recorded as well as the type of assessment: noninvasive or invasive.

A similar process was used with the following domains: continuous intravenous medications, vasoactive intravenous medications, and the coordination of care and patient/family teaching. For example, the expert panel concluded that it was more important to assign a complexity score that was based on the total number of inotropic agents or continuous intravenous medications as opposed to weighting specific medications. The interventions within the coordination of care/teaching/anticipatory guidance to patient/family domain were deemed as ongoing throughout the patient’s hospitalization. These interventions also demonstrated cognitive complexity in ongoing critical thinking and complex decision making and were best reflected by the number and coordination of ancillary services consulted throughout the nurse’s shift.

Low complexity ratings (1-2) were given to activities such as standard infection control procedures and simple dressing changes. Frequent monitoring of vital signs (>15 minutes), airway maintenance, and procedures such as extubation and catheter insertions/removals were assigned a midlevel complexity rating (3). The most complex items (4-5) included activities such as laboratory data interpretation, ECMO-related activities, and

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Domains of care in the Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Monitoring</td>
<td></td>
</tr>
<tr>
<td>2. Intermittent medications</td>
<td></td>
</tr>
<tr>
<td>3. Vasoactive intravenous medications</td>
<td></td>
</tr>
<tr>
<td>4. Continuous intravenous medications</td>
<td></td>
</tr>
<tr>
<td>5. Respiratory</td>
<td></td>
</tr>
<tr>
<td>6. Resuscitation</td>
<td></td>
</tr>
<tr>
<td>7. Infection control</td>
<td></td>
</tr>
<tr>
<td>8. Nursing assessment, management, and intervention</td>
<td></td>
</tr>
<tr>
<td>9. Procedures and testing within the intensive care unit</td>
<td></td>
</tr>
<tr>
<td>10. Activities of daily living/self/assisted care</td>
<td></td>
</tr>
<tr>
<td>11. Transfers/admissions/transport</td>
<td></td>
</tr>
<tr>
<td>12. Assessment of anxiety/coping/mood/family adjustment</td>
<td></td>
</tr>
<tr>
<td>13. Inpatient coordination of care/teaching/anticipatory guidance to patient/family</td>
<td></td>
</tr>
<tr>
<td>14. Professional/environmental management</td>
<td></td>
</tr>
</tbody>
</table>

The panel reached consensus for 14 domains of care.
It is essential to detail the cognitive workload complexity required of critical care nurses.

resuscitation attempts. Description and quantification of the magnitude of nursing care was evident in the total score (phase II). To arrive at a total score, each of the care items with their associated number (1-5) would be summed across the 14 domains of care.

Phase II

Once consensus was reached on the care items and their cognitive workload complexity, phase II of the interpretation of cognitive workload began. The expert panel was charged with constructing classification categories for cognitive workload complexity that were based on total score. Five cognitive workload complexity classification groups (I-V) were identified. In class I, nursing assessment, monitoring, and management are focused on maintaining goal hemodynamics, and the coordination of care/teaching/anticipatory guidance is focused on a seamless transition to non–ICU-level nursing care. In contrast, patients in class V require frequent intensive care nursing assessment, monitoring, and management. Various interventions and procedures may be necessary to achieve and maintain goal hemodynamics. Coordination of care/teaching/anticipatory guidance requires medical/surgical team consultations as does patient/family teaching and support. The resulting tool and cognitive workload classification system was named Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO).

To confirm the capture of the cognitive complexity of nursing care, the final version of the CAMEO tool was completed retrospectively in 75 patients admitted to the cardiac intensive care unit in a 1-month period. Each patient had been admitted for at least 24 hours at the time of review. The clinical lead from the investigative team abstracted data from the electronic medical record for each CAMEO. Descriptive statistics were used to summarize the cohort of patients (Table 2). Each CAMEO was then assessed for frequency of each line item (Table 3). The distribution of total scores for the 75 patients was then used to determine the cut points for the range of scores for final placement in 1 of the 5 CAMEO cognitive complexity classifications (I-V). The cognitive complexity workload for the 75 patients is represented by their classification (see Figure).

Results

Characteristics of Patients

Among the 75 patients, more than 70% of patients were less than 1 year of age, with 52% male and 69% reported as white (Table 2). Eighty-seven percent of patients were admitted for surgical recovery. The median length of CICU stay was 6.50 days (range, 1-207 days).

CAMEO Domains

Fourteen domains of nursing represented the cognitive workload of care delivery. Table 3 illustrates the domains and the list of line items. Table 4 provides the results from the 75 patients’ charts that were reviewed to verify that all aspects of nursing care were captured in the CAMEO. This review did not result in addition of any items to the CAMEO.

CAMEO Complexity Classification

For the 75 patients whose charts were reviewed, the total scores ranged from 25 to 230 with a mean score of 120 and a median score of 124. CAMEO classification for the cohort of 75 was 13% in class I or II, 80% as class III or IV, and 7% as class V (see Figure).

Discussion

The CAMEO tool enables description and quantification of the cognitive workload of pediatric cardiovascular critical care nurses. The nursing process of care is aimed at assessing, synthesizing, planning, and intervening to address actual or potential human responses to health and illness. This process has been described as nonlinear, involving complex reasoning and decision making. While advances in medical and surgical treatments evolve in pediatric critical care so too must nurses’ knowledge and skill expand to provide quality holistic care for patients and parents. Quantification of the complexity of the cognitive workload of the nursing process provides recognition that advanced knowledge and skills are requisite to ensure optimal outcomes for patients. It is essential to detail the cognitive workload complexity required of critical care nurses.

Table 2

Demographics and clinical characteristics of 75 patients in the study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td></td>
</tr>
<tr>
<td>&lt;1 month</td>
<td>30 (40)</td>
</tr>
<tr>
<td>&lt;1 year</td>
<td>23 (31)</td>
</tr>
<tr>
<td>1 year-18 years</td>
<td>16 (21)</td>
</tr>
<tr>
<td>&gt;18 years</td>
<td>6 (8)</td>
</tr>
<tr>
<td>Race:</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>52 (69)</td>
</tr>
<tr>
<td>Nonwhite</td>
<td>23 (31)</td>
</tr>
<tr>
<td>Type of admission</td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td>11 (15)</td>
</tr>
<tr>
<td>Surgical</td>
<td>65 (87)</td>
</tr>
</tbody>
</table>
Table 3

Percentages of the 75 patients receiving nursing care in the 14 domains of the Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) tool

<table>
<thead>
<tr>
<th>Domain and nursing care</th>
<th>No. (%) of patients receiving nursing care</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Monitoring</td>
<td></td>
</tr>
<tr>
<td>Fluid balance (including urine output, chest tubes, peritoneal dialysis, continuous venovenous hemofiltration, drains)</td>
<td>75 (100)</td>
</tr>
<tr>
<td>Noninvasive vital signs: heart rate, respiratory rate, noninvasive blood pressure, oxygen saturation, end-tidal carbon dioxide, near infrared spectroscopy, bispectral index, pupils, expiratory tidal volume, mean airway pressure (ventilator), temperature, loss of consciousness, pain</td>
<td>75 (100)</td>
</tr>
<tr>
<td>Invasive: central venous pressure, umbilical arterial and venous pressures, arterial blood pressure, intracardiac pressures, intracranial pressure, intra-abdominal pressure</td>
<td>61 (80)</td>
</tr>
<tr>
<td>Chest tubes/draains</td>
<td>46 (61)</td>
</tr>
<tr>
<td>Open chest</td>
<td>10 (13)</td>
</tr>
<tr>
<td>Assist device (ventricular assist device, catheter-based pump, oxygenator)</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Extracorporeal membrane oxygenation</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Pacer, temporary wires</td>
<td>23 (31)</td>
</tr>
<tr>
<td>Pacer/automatic implantable cardioverter defibrillator, permanent</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Seizures</td>
<td>5 (6)</td>
</tr>
<tr>
<td>2. Intermittent medications (circle all that apply)</td>
<td></td>
</tr>
<tr>
<td>Nasogastric, nasojejunal, gastric, jejunal, oral</td>
<td>49 (65)</td>
</tr>
<tr>
<td>Topical, otic, ophthalmic, rectal</td>
<td>42 (56)</td>
</tr>
<tr>
<td>Inhalation: metered-dose inhaler, nebulizer</td>
<td>17 (23)</td>
</tr>
<tr>
<td>Patient/nurse controlled analgesia</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Injection: subcutaneous/intramuscular</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Epidural/intrathecal</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Standard intravenous medications</td>
<td>63 (84)</td>
</tr>
<tr>
<td>Fluid bolus</td>
<td>8 (11)</td>
</tr>
<tr>
<td>Chemotherapeutic agents</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Blood products (including 5% albumin)</td>
<td>20 (27)</td>
</tr>
<tr>
<td>Intravenous immunoglobulin G</td>
<td>0 (0)</td>
</tr>
<tr>
<td>3. Vasoactive intravenous medications (circle the number that applies)</td>
<td>1 infusion; 2 infusions; 3 infusions; 4 infusions; &gt;4 infusions</td>
</tr>
<tr>
<td>Dopamine</td>
<td>47 (63)</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>10 (13)</td>
</tr>
<tr>
<td>Esmolol</td>
<td>10 (13)</td>
</tr>
<tr>
<td>Milrinone</td>
<td>26 (35)</td>
</tr>
<tr>
<td>Nipride</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Nitroglycerin</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Phenylephrine</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Vasopressin</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Other(s):</td>
<td>2 (3)</td>
</tr>
<tr>
<td>4. Continuous intravenous medications (circle the number that applies)</td>
<td>1 infusion; 2 infusions; 3 infusions; 4 infusions; &gt;4 infusions</td>
</tr>
<tr>
<td>Calcium gluconate</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Cisatracurium</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Diltiazem</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>62 (83)</td>
</tr>
</tbody>
</table>

Continued
<table>
<thead>
<tr>
<th>Domain and nursing care</th>
<th>No. (%) of patients receiving nursing care</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. Continuous intravenous medications (circle the number that applies)</strong></td>
<td></td>
</tr>
<tr>
<td>1 infusion; 2 infusions; 3 infusions; 4 infusions; &gt; 4 infusions</td>
<td></td>
</tr>
<tr>
<td>Furosemide</td>
<td>22 (29)</td>
</tr>
<tr>
<td>Heparin</td>
<td>34 (45)</td>
</tr>
<tr>
<td>Intralipids</td>
<td>10 (13)</td>
</tr>
<tr>
<td>Midazolam</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Morphine</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Prostaglandin E₁</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Propofol</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Triiodothyronine</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Vecuronium</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Procainamide</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Others</td>
<td>10 (13)</td>
</tr>
<tr>
<td><strong>5. Respiratory (circle all that apply)</strong></td>
<td></td>
</tr>
<tr>
<td>Supplemental oxygen (nasal cannula, high-flow nasal cannula, blowby)</td>
<td>14 (19)</td>
</tr>
<tr>
<td>Bilevel positive airway pressure, continuous positive airway pressure</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Conventional ventilator management</td>
<td>51 (68)</td>
</tr>
<tr>
<td>High-frequency oscillatory ventilation, jet ventilation</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Continuous nebulizer</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Isoflurane/heliox/inhaled nitric oxide, etc</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Lidocaine for suctioning</td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>6. Resuscitation (circle if applicable)</strong></td>
<td></td>
</tr>
<tr>
<td>Resuscitation: cardiopulmonary resuscitation, defibrillation, cardioversion, emergency medicines</td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>7. Infection control (circle if applicable)</strong></td>
<td></td>
</tr>
<tr>
<td>Enhanced precautions (contact, droplet, etc)</td>
<td>26 (39)</td>
</tr>
<tr>
<td><strong>8. Nursing assessment, management, and intervention (circle all that apply)</strong></td>
<td></td>
</tr>
<tr>
<td>Administer procedural sedation</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Neurological/seizure management</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Epidural/intrathecal port management</td>
<td>0 (0)</td>
</tr>
<tr>
<td>External ventricular device/intracranial bolt management</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Pain/sedation/narcotic withdrawal management</td>
<td>58 (77)</td>
</tr>
<tr>
<td>Airway/endotracheal tube maintenance</td>
<td>51 (68)</td>
</tr>
<tr>
<td>Ventilatory support weaning</td>
<td>39 (52)</td>
</tr>
<tr>
<td>Critical airway/fresh tracheostomy management</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Tracheostomy care</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Spit fistula care</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Endotracheal tube/tracheostomy suctioning</td>
<td>46 (61)</td>
</tr>
<tr>
<td>Oral/nasopharyngeal/nasal suctioning</td>
<td>46 (61)</td>
</tr>
<tr>
<td>Cough assist vest</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Chest physiotherapy</td>
<td>17 (23)</td>
</tr>
<tr>
<td>Arrhythmia management</td>
<td>8 (11)</td>
</tr>
<tr>
<td>Pacing wire removal</td>
<td>2 (3)</td>
</tr>
</tbody>
</table>

*Continued*
### Table 3

**Continued**

<table>
<thead>
<tr>
<th>Domain and nursing care</th>
<th>No. (%) of patients receiving nursing care</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8. Nursing assessment, management, and intervention (circle all that apply)</strong></td>
<td></td>
</tr>
<tr>
<td>Blood product rapid infuser management</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Postprocedural bleeding management</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Temperature/fever regulation</td>
<td>26 (35)</td>
</tr>
<tr>
<td>Cooling/warming blanket</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Gastrointestinal/feeding tube management</td>
<td>24 (32)</td>
</tr>
<tr>
<td>Gastrointestinal/feeding tube insertion/removal</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Chest tube/Blake/Jackson-Pratt/peritoneal dialysis drain management</td>
<td>32 (43)</td>
</tr>
<tr>
<td>Gastrointestinal/ostomy tube care</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Bladder scanner</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Genitourinary (urinary catheter/ureteral) tube management</td>
<td>24 (32)</td>
</tr>
<tr>
<td>Urinary catheter insertion/removal/straight catheterization</td>
<td>8 (11)</td>
</tr>
<tr>
<td>Peritoneal dialysis</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Sequential compression devices</td>
<td>8 (11)</td>
</tr>
<tr>
<td>Splints/orthotics</td>
<td>0 (0)</td>
</tr>
<tr>
<td>External traction</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Wound care/dressing change; simple</td>
<td>32 (43)</td>
</tr>
<tr>
<td>Wound care/dressing change; complex</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Vacuum-assisted wound management</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Peripheral intravenous catheter site management</td>
<td>51 (68)</td>
</tr>
<tr>
<td>Peripheral intravenous catheter insertion/removal</td>
<td>10 (13)</td>
</tr>
<tr>
<td>Peripheral intravenous catheter tubing change/infusion change</td>
<td>29 (39)</td>
</tr>
<tr>
<td>Central venous/arterial/intracardiac/peripherally inserted catheter maintenance/indwelling port</td>
<td>61 (81)</td>
</tr>
<tr>
<td>Fluid balance</td>
<td>51 (68)</td>
</tr>
<tr>
<td>Drug mixture (intravenous)</td>
<td>8 (11)</td>
</tr>
<tr>
<td>Drug dose calculation</td>
<td>56 (75)</td>
</tr>
<tr>
<td>Point-of-care testing</td>
<td>17 (23)</td>
</tr>
<tr>
<td>Capillary/heel puncture</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Noncannulated site (peripheral stick)</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Arterial venous port</td>
<td>51 (68)</td>
</tr>
<tr>
<td>Specimen (cultures/laboratory samples) management</td>
<td>46 (61)</td>
</tr>
<tr>
<td>Laboratory data interpretation (acid/base balance, electrolytes, hematology)</td>
<td>53 (71)</td>
</tr>
<tr>
<td>End-of-life care/postmortem care</td>
<td>2 (3)</td>
</tr>
</tbody>
</table>

| **9. Procedures/testing within the intensive care unit (circle all that apply)** | |
| Intubation | 0 (0) |
| Extubation | 8 (11) |
| Bronchoscopy | 2 (3) |
| Cardioversion | 0 (0) |
| Chest tube/drain placement | 5 (7) |
| Chest tube/drain removal | 0 (0) |
| Electrocardiography | 14 (19) |
| Echocardiography | 0 (0) |
| Extracorporeal membrane oxygenation: cannulation/decannulation/circuit change | 2 (3) |

*Continued*
### Table 3 Continued

<table>
<thead>
<tr>
<th>Domain and nursing care</th>
<th>No. (%) of patients receiving nursing care</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>9. Procedures/testing within the intensive care unit (circle all that apply)</strong></td>
<td></td>
</tr>
<tr>
<td>Balloon atrial septostomy</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Chest exploration/opening/closure</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Abdominal exploration</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Vacuum-assisted wound dressing change</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Vacuum-assisted wound dressing insertion</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Computed tomography of head</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Chest radiography</td>
<td>24 (32%)</td>
</tr>
<tr>
<td>Electroencephalography</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Ultrasound (head, abdomen, etc)</td>
<td>8 (11)</td>
</tr>
<tr>
<td>Lumbar puncture</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Central venous, intracardiac, arterial, umbilical, peripherally inserted catheter insertion</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Central venous, intracardiac, arterial, umbilical, peripherally inserted catheter removal</td>
<td>10 (13)</td>
</tr>
<tr>
<td>Plasmapheresis</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Hemofiltration</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Continuous venovenous hemofiltration</td>
<td>2 (3)</td>
</tr>
<tr>
<td><strong>10. Activities of daily living/self/assisted cares (circle all that apply)</strong></td>
<td></td>
</tr>
<tr>
<td>Oral feeding with assistance</td>
<td>8 (11)</td>
</tr>
<tr>
<td>Bottle feeding</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Nasogastric, nasojejunal, gastric, jejunal feedings</td>
<td>26 (35)</td>
</tr>
<tr>
<td>Skin care, complex</td>
<td>34 (45)</td>
</tr>
<tr>
<td>Toileting</td>
<td>20 (27)</td>
</tr>
<tr>
<td>Ambulation with assistance</td>
<td>20 (27)</td>
</tr>
<tr>
<td><strong>11. Transfers/admissions/transport (circle all that apply)</strong></td>
<td></td>
</tr>
<tr>
<td>Floor</td>
<td>10 (13)</td>
</tr>
<tr>
<td>Home</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Operating room</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Magnetic resonance imaging</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Catheterization laboratory</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Radiology (computed tomography, ultrasound, radiography)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Interventional radiology</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Outside facility</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Emergency department</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Nuclear medicine</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Other</td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>12. Assessment of anxiety/coping/mood/family adjustment (circle if applicable)</strong></td>
<td></td>
</tr>
<tr>
<td>Noneffective</td>
<td>14 (19)</td>
</tr>
<tr>
<td><strong>13. Inpatient coordination of care/teaching/anticipatory guidance to patient/family (circle the number that applies)</strong></td>
<td></td>
</tr>
<tr>
<td>Case management/consultant (social work, child life, resource specialist, psychology, physical/occupational therapy, lactation, interpreter services)</td>
<td>12 (16)</td>
</tr>
<tr>
<td>Nutrition (calories per kilogram per day)</td>
<td>39 (52)</td>
</tr>
<tr>
<td>Admission/discharge</td>
<td>8 (11)</td>
</tr>
</tbody>
</table>

Continued
care nurses, not only to continue the advancement of the nursing profession but also to provide guidance for educational innovations in theory and clinical skills necessary to care for such increasingly complex patients.

The CAMEO quantifies cognitive workload according to cognitive complexity and not time as associated with traditional methods of human factors engineering (HFE). HFE techniques have been useful in streamlining processes, increasing productivity, and decreasing costs while maintaining quality in health care. However, these processes tend to be control-based; for example, utilization of supplies or the observable direct care activities of medication delivery.\textsuperscript{30,31} The limitations of HFE analyses are demonstrated when the work under measure is nonlinear, requires discretion, and is self-paced and unpredictable.\textsuperscript{32} Nursing care is based on assessment of patients and response to the clinical situation. Dynamic in nature, it involves the intellectual processing of ongoing assessment, critical thinking, and clinical decision making including the ability to reprioritize on the basis of patients’ changing status.

Measuring the cognitive workload captures the intellectual processing of information and decision making that defines nursing practice but is underestimated when measuring nursing workload in minutes and frequency of completing nursing tasks.\textsuperscript{22,30} Research has shown that nurses’ cognitive activity concerning patients is ongoing and may actually be most concentrated away from the bedside.\textsuperscript{22,30} In fact, a significant difference was found between the amount of time spent in a particular location versus the cognitive focus on a particular patient.\textsuperscript{22,30} Researchers have concluded that the intense but invisible activity of continually processing nursing

### Table 3

<table>
<thead>
<tr>
<th>Domain and nursing care</th>
<th>No. (%) of patients receiving nursing care</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Inpatient coordination of care/teaching/anticipatory guidance to patient/family (circle the number that applies)</td>
<td></td>
</tr>
<tr>
<td>Orientation to the unit/floor</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Disease process</td>
<td>36 (48)</td>
</tr>
<tr>
<td>Medication</td>
<td>32 (43)</td>
</tr>
<tr>
<td>Procedure/treatment</td>
<td>22 (29)</td>
</tr>
<tr>
<td>Family presence facilitation</td>
<td>19 (25)</td>
</tr>
<tr>
<td>Postoperative education</td>
<td>29 (39)</td>
</tr>
<tr>
<td>Preoperative education</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Multidisciplinary care meeting/family meeting</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Organ donation</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Other</td>
<td>0 (0)</td>
</tr>
<tr>
<td>14. Professional/environmental management (circle all that apply)</td>
<td></td>
</tr>
<tr>
<td>Clinical practice guidelines/management plans</td>
<td>34 (45)</td>
</tr>
<tr>
<td>Delegation to unlicensed personnel</td>
<td>14 (19)</td>
</tr>
<tr>
<td>Documentation</td>
<td>75 (100)</td>
</tr>
<tr>
<td>Technology management</td>
<td>56 (75)</td>
</tr>
<tr>
<td>Incident reporting (Safety Event Reporting System)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Precept: employee</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Precept: student</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Research/quality data collection</td>
<td>36 (48)</td>
</tr>
<tr>
<td>Staff development (side by sides, resource)</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Shift report, complex</td>
<td>73 (97)</td>
</tr>
<tr>
<td>Sitter</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Security</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Unit/institution meetings</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>
care may be one reason why time and frequency of task used to guide nursing assignments and staffing ratios remain unsatisfactory.22,30

The 14 domains of the CAMEO describe not only the direct and but also the indirect cognitive processes associated with nursing care. The current pediatric health care environment characterized by increasing patient acuity, complex technology, and regulatory requirements has increased nursing responsibility and accountability. During the process of identifying domains of care, the expert panel agreed that 14 domains were needed in order to encompass the cognitive workload complexity and magnitude of daily, expected care practices. For several domains, the cognitive workload complexity related to the number of similar activities the nurse managed simultaneously as volume contributed more to complexity than did the particular characteristics of any 1 item. It is this cognitive stacking as described by Ebright and colleagues21 that truly reflects the dynamic nature of nursing. The cognitive pathway of today’s nurse is complex and nonlinear. Nurses are frequently challenged with multiple tasks that need to occur simultaneously because of the patient’s symptoms and status. The ability to prioritize and reorganize care on the basis of knowledge and understanding of potential outcomes is essential.

Particularly important to the expert panel was developing the domain of professional and environmental management to include the numerous indirect responsibilities linked to the cognitive workload of nursing care. For example, serving as a preceptor for new staff entails teaching, guiding, critiquing, and supporting, all of which are done while also providing patient care. Although serving as a preceptor is an important professional responsibility, it definitely increases the level of cognitive workload while providing patient care.

The assignment of a cognitive workload complexity rating (1-5) for each line item illustrates the cognitive stacking of nursing care and how that contributes to the final CAMEO classification system. The expert panel was able to distinguish a difference in cognitive workload complexity, allowing for a distribution of line items on a scale of 1 to 5 with most line items considered a 1, 2, or 3 and a limited number of items rated as 4 or 5. However, it was the magnitude of all the line items that provided a final classification of cognitive workload complexity. In the cohort of 75 patients, most patients were classified as III or IV, which is reflective of nursing care required to support the hemodynamic status of patients, coordinate care, and manage the information needs of the patient’s family.

A number of productivity tools measured frequency of care and time spent delivering care as a proxy for patient acuity to inform staffing and resource use.1,4,6,9 Although these tools have some value in determining staffing needs, the expert panel did not find them adequate as they did not address the extensive, ongoing cognitive activity that constituted every nurse’s practice. Also relevant and missing in these tools were ways in which the environment contributed to the cognitive complexity of care. The depth of knowledge and management of resources required for delivery of safe, effective, efficient care demands an ever-increasing amount of nursing work.

Moving toward a model of nursing care that is patient and family centered supports the demonstration of optimal outcomes.33 The comprehensive lens of the CAMEO enables needs of patients (and their families) to be clearly delineated so that those needs can be matched with a nurse’s skill set as conceptually described in the American Association of Critical-Care Nurses’ Synergy Model for Patient Care.33 Creating a nursing tool to illustrate the cognitive complexity of the work that critical care nurses perform provides a more comprehensive narrative of nursing practice and details nurses’ vital role to key stakeholders in health care policy at the organizational level and beyond.

Limitations

The development and pilot testing of the CAMEO tool was conducted in 1 pediatric cardiac intensive care unit. Any statements of external generalizability require further multisite testing, which will be a focus for future study.

Figure Distribution of 75 patients by Complexity Assessment and Monitoring to Ensure Optimal Outcomes (CAMEO) classification.
Use of the modified Delphi approach to develop the CAMEO tool was necessary to create the description and quantification of cognitive complexity. This method has been used previously; however, it is noted that there is bias in subjectivity. Empirical testing of the CAMEO will be necessary to support future validation of the tool. Although retrospective assessment is also noted to have numerous limitations, the approach has been considered valid in tool development. The length of the CAMEO in terms of line items may also be considered a limitation. Work is underway to streamline the CAMEO and focus on items beyond basic intensive nursing care that significantly contribute to classifying the complexity of nursing care.

Conclusions

The CAMEO tool was comprehensive in describing and quantifying the complexity of cognitive workload practiced by pediatric cardiovascular

<table>
<thead>
<tr>
<th>Domain</th>
<th>Summary of care items from retrospective review of 75 charts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring</td>
<td>Standard intensive care with noninvasive monitoring was reported in 100% of the patients, with invasive monitoring present in 81%. The rating of cognitive complexity for the care items of fluid balance, noninvasive monitoring, and invasive monitoring was based on frequency of assessment. Additional monitoring items included chest tubes/drains, open chest, ventricular assist devices, extracorporeal membrane oxygenation, pacing wires/pacemaker, and seizure monitoring. The range of cognitive complexity for each item was 2 to 5 points.</td>
</tr>
<tr>
<td>Intermittent medications</td>
<td>Most frequent were standard intravenous medications (84%), nasogastric/gastric tube medications (65%), topical medications (56%), and administration of blood products (26%). The cognitive complexity for these items ranged from 1 to 4.</td>
</tr>
<tr>
<td>Vasoactive intravenous medications</td>
<td>Most frequent vasoactive infusions were dopamine (62%) and milrinone (35%). Cognitive complexity based on number managed but could not exceed 5.</td>
</tr>
<tr>
<td>Continuous intravenous medications</td>
<td>The most frequently managed infusions were fentanyl (83%), heparin (45%), and furosemide (29%). Cognitive complexity based on number managed but could not exceed 5.</td>
</tr>
<tr>
<td>Respiratory</td>
<td>A number of different strategies could be used to support the patient’s respiratory status. Most frequent was conventional ventilation (68%) with cognitive complexity range of 1 point to 5 points per item.</td>
</tr>
<tr>
<td>Resuscitation</td>
<td>Three components: compressions, defibrillation, and medications. Use of any of the 3 components equalled a cognitive complexity rate of 5.</td>
</tr>
<tr>
<td>Infection control</td>
<td>Infection control precautions were a frequent necessity in the intensive care environment; enhanced precautions required in 39% of patients.</td>
</tr>
<tr>
<td>Nursing assessment, management, and intervention</td>
<td>Each care item was considered nurse initiated. Of the 48 items, 12 (pain, sedation, narcotic withdrawal management, airway/endotracheal tube management, central catheter management) were present &gt; 50%. Cognitive complexity for items ranged from 1 to 5; 19 care items were a 2 and 14 care items were a 3.</td>
</tr>
<tr>
<td>Procedures and testing within the intensive care unit</td>
<td>Most common of the 25 items were chest radiograph (32%), electrocardiogram (19%), and central/arterial catheter removal (13%). Cognitive complexity ranged from 1 to 5; 9 care items were a 4 or 5.</td>
</tr>
<tr>
<td>Activities of daily living/self/assisted care</td>
<td>Feeding nasogastric tube/oral (48%), skin care (45%), and ambulation (26%) were most common. The cognitive complexity for each item was rated as a 1 or 2.</td>
</tr>
<tr>
<td>Transfers/admissions/transport</td>
<td>Most common of the 11 distinct items were transfer to the operating room (16%), patient acute care area (13%), and catheterization laboratory (6%). The cognitive complexity was similar being either 3 or 4.</td>
</tr>
<tr>
<td>Assessment of anxiety/coping/mood/family adjustment</td>
<td>Coping defined as effective coping requiring usual nursing support or noneffective coping requiring intensive support of the nurse and/or the extended health care team and cognitive complexity rate of 2.</td>
</tr>
<tr>
<td>Inpatient coordination of care/teaching/anticipatory guidance to patient/family</td>
<td>Most common items were teaching about the disease process (48%), medications (42%), and postoperative care (39%). Depending on the number of items addressed, cognitive complexity can range from 1 to a maximum of 15.</td>
</tr>
<tr>
<td>Professional/environmental management</td>
<td>These items represented the cognitive complexity beyond direct patient care but linked to patient support and the growth and support of the profession or environment. Cognitive complexity of each item ranges from 1 to 4 with the assumption that multiple items could occur within the nursing shift.</td>
</tr>
</tbody>
</table>
critical care nurses. The use of CAMEO informs staffing needs through cognitive workload, allowing synergy among the needs of patients and their families and the knowledge and skills of nurses. Understanding nursing care beyond frequency and time required for “tasks” is necessary to fully inform the dialogue about professional practice models, nurse staffing decisions, and allocation of resources to best serve patients and their families.

Next Steps

Further adaptation of the CAMEO to qualify and quantify nursing care has begun in the medical-surgical and neonatal intensive care units, with the goal of having 1 tool. Empirical study will be conducted to support validation and use of the CAMEO beyond a single institution. The CAMEO will also move from a paper tool to an electronic document to inform real-time use of nursing resources and benchmarking.

ACKNOWLEDGMENTS

The investigators acknowledge the following for their contributions and support: the expert panel and nursing staff in the cardiac intensive care unit at Boston Children’s Hospital, Boston, Massachusetts, as well as Dr Sandra Mott, Hillary Kuzdeba, and Courtney Porter for their expert editing.

FINANCIAL DISCLOSURES

This work was supported by a Boston Children’s Hospital Program for Patient Safety and Quality Research Grant Award for 2009 and 2012.

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INFLUENCE OF INSTITUTIONAL GUIDELINES ON ORAL HYGIENE PRACTICES IN INTENSIVE CARE UNITS

By Hiroko Kiyoshi-Teo, RN, PhD, and Mary Blegen, RN, PhD

Background Maintaining oral hygiene is a key component of preventing ventilator-associated pneumonia; however, practices are inconsistent.

Objectives To explore how characteristics of institutional guidelines for oral hygiene influence nurses’ oral hygiene practices and perceptions of that practice.

Methods Oral hygiene section of a larger survey study on prevention of ventilator-associated pneumonia. Critical care nurses at 8 hospitals in Northern California that had more than 1000 ventilator days in 2009 were recruited to participate in the survey. Twenty-one questions addressed oral hygiene practices and practice perceptions. Descriptive statistics, analysis of variance, and Spearman correlations were used for analyses.

Results A total of 576 critical care nurses (45% response rate) responded to the survey. Three types of institutional oral hygiene guidelines existed: nursing policy, order set, and information bulletin. Nursing policy provided the most detail about the oral hygiene care; however, adherence, awareness, and priority level were higher with order sets ($P < .05$). The content and method of disseminating these guidelines varied, and nursing practices were affected by these differences. Nurses assessed the oral cavity and used oral swabs more often when those practices were included in institutional guidelines.

Conclusions The content and dissemination method of institutional guidelines on oral hygiene do influence the oral hygiene practices of critical care nurses. Future studies examining how institutional guidelines could best be incorporated into routine workflow are needed. (American Journal of Critical Care. 2015;24:309-317)
Ventilator-associated pneumonia (VAP) is still a common nosocomial infection in critical care units despite continuous prevention efforts. Reported VAP rates are as high as 6.0 per 1000 ventilator days, with attributable mortality rates from 15% to 50%. VAP increases the duration of mechanical ventilation and hospital length of stay by a mean of 7 to 9 days, costing $10,000 to $40,000 per case.

Maintaining oral hygiene is one of the key components of VAP prevention. For intubated patients, endotracheal tube placement provides a direct pathway for bacteria to enter the body, reduces the cough reflex, and decreases salivary flow, which inhibits mechanical removal of plaque by saliva. Ideally, oral hygiene care of patients receiving mechanical ventilation should consist of oral cavity assessment, swabbing the oral cavity using an oral swab or “toothette,” toothbrushing, suctioning, oral rinse, and providing moisture. Professional organizations recommend that hospitals implement comprehensive oral hygiene programs to prevent VAP. However, professional recommendations often lack the specifics needed to be practical in bedside practice.

The American Association of Critical-Care Nurses (AACN) guideline presents one of the most comprehensive lists of oral hygiene recommendations. Their recommendations are as follows: (1) brush teeth, gums, and tongue at least twice a day using a soft pediatric or adult toothbrush; (2) provide oral moisture to oral mucosa and lips every 2 to 4 hours; and (3) use an oral chlorhexidine gluconate (0.12%) rinse twice a day during the perioperative period for adult patients who undergo cardiac surgery.

Practices of oral hygiene vary for critically ill patients. Swabbing of the oral cavity using a toothette is most frequently practiced. A survey of critical care nurses revealed that approximately 70% to 92% of nurses practice swabbing at least every 4 hours. Although oral swabbing may provide comfort, it is not as effective as toothbrushing, in which motions of bristles physically remove dental plaque, which can become a breeding ground for pathogenic bacteria. However, toothbrushing is practiced less often, with only 39% to 65% of nurses brushing their patients’ teeth every 12 hours or more often.

Institutional guidelines or recommendations, terms that are used interchangeably in this article, provide directions and expectations for nursing practice and are one of the top sources of information for nurses. Organizations often use such guidelines to implement evidence-based practices and to standardize care. However, only about half of nurses reported having oral hygiene guidelines at their institutions. Nurses may find themselves liable if they do not practice according to institutional standards. Yet factors affecting the uptake of the guideline recommendations are not well understood. Furthermore, even when nurses do have institutional guidelines for a nursing procedure, such guidelines are not adhered to consistently. Reasons identified for nonadherence include concern for patients’ discomfort and fear of adverse events, lack of resources, disagreement with the guideline content, and lack of belief in the effectiveness of the strategies. Nurses also perceived that cleaning the oral cavity is a difficult and unpleasant task.

We conducted a multihospital survey study in year 2010-2011 in an effort to understand the factors affecting critical care nurses’ VAP prevention practices (oral hygiene, head-of-bed elevated positioning, spontaneous breathing trial, and hand hygiene). We observed great variability in the institutional oral hygiene guidelines and oral hygiene practices. This article is focused on the oral hygiene component of the study to explore how characteristics of institutional oral hygiene guidelines influence nurses’ oral hygiene practices and perceptions of that practice.

Methods

Study Design and Sample

Oral hygiene practices of critical care nurses were investigated through a large cross-sectional descriptive study on VAP prevention practices and factors associated with guideline adherence. Eight hospitals in Northern California that were participating in a patient safety collaborative (The Bay Area Patient Safety Collaboration) and had large numbers of patients receiving mechanical ventilation...
(>1000 ventilator days in 2009) were enrolled. Paper surveys were distributed to all critical care nurses with direct patient care responsibilities at these institutions. Institutional oral hygiene guidelines were obtained for each of the patient care areas.

**Instruments**

The VAP prevention survey included 21 questions on oral hygiene. Two previously published surveys were used to create questions. The “Oral Care Practice” survey27 is one of the most rigorously created surveys to address oral care practices. The content validity index score was 97.1% agreement, interrater reliability scores were 0.86 and 0.83, and test-retest reliability was 0.82 to 0.86. We used questions that asked for frequency of oral assessment, use of oral swab (ie, toothette, foam swab), and toothbrushing. We have also used questions with slight modifications from the “Attitudes Regarding Practice Guidelines” survey28,29 to address adherence to oral hygiene guidelines and attitudes toward guidelines. The Cronbach α for the original survey was 0.83. Permissions to use the surveys were obtained from both survey creators. The survey also included demographic variables.

The face and content validity of the VAP prevention survey were established by 13 content and survey experts (critical care nurses enrolled in a nursing graduate program and dissertation committee). Reliability testing was conducted with hospital 1’s critical care nurse participants, who volunteered to retake the survey 2 weeks after the initial participation (n = 20). Reliability scores for the oral hygiene section of the survey were acceptable, given the small sample of participants (Table 1). Further information on validity and reliability testing is reported elsewhere.26 Adherence to institutional guidelines was measured by a single item: “I practiced oral hygiene per policy/guideline,” and responses were reported on a 4-point Likert scale (1 = never, 2 = sometimes, 3 = most of the time, and 4 = always). The adjective “exactly” was omitted from the original version of the survey (“I practice oral hygiene exactly per policy/guideline,” test-retest reliability: $r = 0.35$) as most procedures must be adjusted slightly to fit the patient’s situation. Practice perceptions included awareness, priority levels, and attitudes. Awareness and priority levels were single items with test-retest reliabilities of 0.67 and 0.58, respectively. Attitude was a mean score of the following items: (1) agreement with the guideline content, (2) self-efficacy, (3) outcome expectancy, and (4) intention. Test-retest reliability for the attitude scale was 0.81 with a Cronbach α of 0.61. Test-retest reliability for frequency of oral hygiene interventions was acceptable ($r = 0.58$ and 0.64) except for the oral swabs ($r = -0.30$). The raw data were closely examined to explore the

<table>
<thead>
<tr>
<th>Item/scale (subscale)</th>
<th>No. of items</th>
<th>Survey questions</th>
<th>Reliability score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adherence</td>
<td>1</td>
<td>[ORIGINAL] I provide oral hygiene exactly per policy/guideline with the last 4 patients that I took care of. [FINAL] I practiced oral hygiene per policy/guideline with the last 4 ventilated patients that I cared for.</td>
<td>0.35 0.61</td>
</tr>
<tr>
<td>Awareness</td>
<td>1</td>
<td>How much have you read the oral hygiene policy/guideline of your unit?</td>
<td>0.67 0.58</td>
</tr>
<tr>
<td>Priority</td>
<td>1</td>
<td>How do you rate the priority level of oral hygiene for mechanically ventilated patients?</td>
<td>0.58 0.61</td>
</tr>
<tr>
<td>Attitudes</td>
<td>4</td>
<td>I agree with the oral hygiene policy/guideline. I am confident that I can perform oral hygiene as recommended in the policy/guideline. Using the oral hygiene policy/guideline will reduce VAP. I plan to use the oral hygiene policy/guideline whenever I can.</td>
<td>0.81 0.61</td>
</tr>
<tr>
<td>Oral hygiene practices</td>
<td>In general, how often do you provide oral hygiene care for mechanically ventilated patients?</td>
<td>0.58 0.61</td>
<td></td>
</tr>
<tr>
<td>Oral assessment frequency</td>
<td>1</td>
<td></td>
<td>0.64</td>
</tr>
<tr>
<td>Tooth swab frequency</td>
<td>1</td>
<td></td>
<td>-0.30</td>
</tr>
<tr>
<td>Toothbrushing frequency</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: NA, not applicable; VAP, ventilator-associated pneumonia.

*Original wording was used to examine test-retest reliability. Wording was changed for the final survey due to test-retest result.

Retest results: Out of 20 retest participants, 7 reported exactly the same frequency; another 7 nurses reported differently but within a 2-hour time frame between test and retest responses, 4 reported more than 2 hour difference between test and retest, and 2 did not respond to the retest question.
reasons why the reliability score for oral swabs was so different. Out of 20 retest respondents, 7 nurses gave exactly the same response, and another 7 nurses reported a different frequency but their reported frequency differed by 2 hours or less between test and retest responses. Also, compared with toothbrushing and oral cavity assessment, oral swabbing occurred more frequently and spontaneously depending on patient’s situation such as the amount of oral secretions or the patient’s thirst. Thus, we attributed the oral swab reliability score to the small sample size.

### Procedures
The surveys were distributed between June 2010 and April 2011 after institutional review boards from each study site approved the study. The author distributed surveys in person, through hospital mailboxes, or by placing them in break rooms. Respondents received $3 to $5 gift cards for their participation, depending on the vendor that was available to them. Participants’ names were voluntarily submitted separately from the survey responses in order to receive the gift card. In addition to approval from the institutional review board at each hospital involved, approval for the study was secured from the institutional review board at the University of California, San Francisco.

The return of the completed survey indicated participants’ consent to participate in this study.

### Data Analysis
Deidentified survey responses were entered into an Excel (Microsoft Corp) spreadsheet by the lead researcher and the research assistant. Every other data entry was double-checked to ensure accuracy and then was imported into the SPSS statistics software package (IBM SPSS, Inc). Descriptive analyses were used to identify respondents’ characteristics and current practices related to oral hygiene. Analysis of variance was used to explore the difference among institutional guidelines in regard to adherence and practice perceptions. The Scheffé method, the most conservative method for reducing the risk of a type I error, was selected for post-hoc analyses. Spearman correlations were used to examine the strength of relationships among adherence to oral hygiene guidelines, practice perceptions, and nurses’ characteristics.

### Results
Critical care nurses from 18 intensive care units (ICUs), representing 1 academic, 3 public, and 4 private nonprofit hospitals, were included in the study (Table 2). Licensed bed sizes ranged from 271 to 574 beds. Ventilator days ranged from 1991 to 5746.
7534 days per year, and VAP rates ranged from 0 to 2.51 per 1000 ventilator days. Institutional oral hygiene recommendations were implemented as either a nursing policy (4 hospitals), order set (2 hospitals), or information bulletin (2 hospitals). Surveys were completed by 576 ICU nurses (44.6% response rate) representing diverse critical care specialties. Half of the units were medical/surgical and the others were cardiac, trauma, medical/cardiology, neurological, burn, and surgical ICUs. The mean ICU experience was 12.40 years and the mean work hours per week was 33.91 hours. Nearly three-quarters of the nurses had bachelor’s level or higher education. About 40% of the nurses were certified in a nursing specialty (e.g., critical care registered nurse, trauma nurse). More than half of the respondents had recently taken care of patients receiving mechanical ventilation.

### Institutional Oral Hygiene Guidelines

Documents providing directions and expectations for oral hygiene practices in critical care settings, which we call institutional oral hygiene guidelines in this article, existed in all hospitals. Even when the institution had multiple critical care units, all units used the same document. Characteristics of the 3 types of institutional oral hygiene guidelines (nursing policy, order set, and information bulletin) are listed in Table 3. Nursing policies were official documents typically created by nursing committees for nurses and labeled as “standard of care,” “protocol,” or “procedure manual.” Nursing policies were available to nurses electronically through the intranet or a paper medium such as a “nursing procedure binder.” These policies typically offered the most comprehensive and detailed directions on oral hygiene. Some of these policies provided step-by-step processes including instructions on positioning of patients, what to assess, where and how long to brush, and effective brushing strokes. Nursing policies were the only ones to address oral assessment in the document. Order sets were official documents used as a communication tool between providers and nurses.

### Table 3

**Characteristics of institutional oral hygiene guidelines**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Nursing policy&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Order set&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Information bulletin&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper or electronic availability</td>
<td>Paper or electronic</td>
<td>Paper</td>
<td>Paper</td>
</tr>
<tr>
<td>Contents addressed&lt;sup&gt;d&lt;/sup&gt;</td>
<td>All</td>
<td>No</td>
<td>Variable</td>
</tr>
<tr>
<td>Expected outcomes</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Supplies</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Procedure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient position</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Suction before oral hygiene care</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Oral cavity assessment</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Frequency</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Areas to assess</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Oral swab</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>All</td>
<td>Variable</td>
<td>Variable</td>
</tr>
<tr>
<td>Areas to swab</td>
<td>Variable</td>
<td>Variable</td>
<td>No</td>
</tr>
<tr>
<td>Swabbing strokes</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Toothbrush</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>Variable</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>Areas to brush</td>
<td>Variable</td>
<td>Variable</td>
<td>No</td>
</tr>
<tr>
<td>Brushing strokes</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Oral antimicrobial or cleaning agent use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>All</td>
<td>All</td>
<td>Variable</td>
</tr>
<tr>
<td>Moisture application</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Reference cited</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Length, pages</td>
<td>1-2</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

<sup>a</sup> Hospitals 1, 3, 4, and 6.

<sup>b</sup> Hospitals 7 and 8.

<sup>c</sup> Hospitals 2 and 5.

<sup>d</sup> All = all institutions, Variable = some institutions, No = none of the institutions.
Procedures for oral hygiene were addressed in admission order sets or ventilator care order sets but provided minimal directions related to oral hygiene such as indicating the frequency and specific areas of an oral cavity to swab. Information bulletins were unofficial documents posted in the critical care units as an informal communication tool for bedside nurses. Contents of these bulletins were even more brief such as “tooth brush every 4-6 hours” or “use chlorhexidine every 12 hours.”

**Oral Hygiene Practices**

We examined how frequencies of oral hygiene practices may or may not be influenced by whether the institutional guidelines provided recommendations on frequencies regardless of guideline types. The frequency recommended in the guidelines varied widely, as did the actual frequency of oral hygiene in practice (Table 4). For oral assessment and oral swabbing, just having a frequency recommended was associated with more frequent assessment of the oral cavity and use of oral swabs ($P < .001$). In contrast, even when frequencies were included in institutional guidelines, it did not seem to influence actual toothbrushing practices ($P = .06$).

**Guideline Adherence and Practice Perceptions**

Table 5 presents mean scores for adherence and practice perceptions categorized by the types of institutional guidelines for oral hygiene. Factors associated with adherence to oral hygiene guidelines were nurses’ awareness, priority, and attitudes (agreement, self-efficacy, outcome expectancy, and intention). A score of 4 represented the most favorable behavior or perceptions (1-4 Likert scaling). Adherence scores were from 3.25 to 3.59 (mean, 3.35). Adherence, awareness, level of priority, and outcome expectancy scores differed significantly depending on the types of institutional guidelines. Adherence, awareness, and priority level scores were significantly higher for order sets than for nursing policies or information bulletins (see Table 5). On the other hand, outcome expectancy was highest for information bulletin ($P = .002$). Scores for agreement, self-efficacy, and intention were not significantly different among nursing policy, order set, and information bulletin ($P = .68$, $P = .09$, $P = .91$, respectively).

Table 5 also presents the Spearman correlations between oral hygiene guideline adherence guidelines and practice perceptions. Statistically significant, moderate correlations existed between adherence and practice perceptions such as level or priority ($r = 0.26$), self-efficacy ($r = 0.27$), and outcome expectancy ($r = 0.25$). No significant associations were found between oral hygiene guideline adherence and demographic variables.

**Discussion**

This article reports on institutional oral hygiene guidelines, nurses’ oral hygiene practices, and nurses’ perceptions of oral hygiene practice. Oral hygiene guidelines are implemented via nursing policies, order sets, or information bulletins. Having recommendations on practice frequency was directly associated with more frequent oral assessment and oral swabbing, but not with more frequent toothbrushing. Nursing policies provided the most detailed practice recommendations but were associated with the lowest levels of adherence, priority, agreement with the content, and self-efficacy.

**Institutional Oral Hygiene Guidelines**

Institutional oral hygiene guidelines were present in all of the participating hospitals. This finding exceeds previously reported rates of 50% to 72% of respondents having nursing oral care policies for orally intubated critically ill patients. Hospitals in this study were part of a local patient safety collaborative; thus, this may have affected the availability of institutional recommendations for oral
Compared with the AACN’s practice alert and the Institute for Healthcare Improvement’s oral hygiene recommendations, many of the institutions offered more comprehensive recommendations regarding oral care practices such as positioning or suctioning of a patient. Despite the limited scientific data on oral hygiene practices, some hospitals had nursing policies that even included appropriate brushing strokes and specific areas to brush. The depth and breadth of the guidelines varied. Nursing policies were more comprehensive than were order sets or information bulletins. Although nurses use nursing policy as an information source for evidence-based practice, hospitals with nursing policies for oral hygiene had lower adherence and less positive perceptions of practice. Awareness and level of priority were highest with order sets, perhaps because nurses often review provider orders as part of their practice.

### Table 5

**Adherence to institutional oral hygiene guidelines, practice perceptions, and correlations**

<table>
<thead>
<tr>
<th>Adherence and perceptions</th>
<th>Overall score</th>
<th>a. Nursing policy (n = 336-364)</th>
<th>b. Order set (n = 95-97)</th>
<th>c. Information bulletin (n = 76-96)</th>
<th>(P^a)</th>
<th>Correlations with adherence to institutional guidelines(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adherence to institutional guidelines</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I practiced oral hygiene per guideline/policy with the last 4 ventilator patients that I cared for. ((1 = \text{never}, 2 = \text{some of the time}, 3 = \text{most of the time}, 4 = \text{always}))</td>
<td>3.35</td>
<td>3.25</td>
<td>3.59</td>
<td>3.46</td>
<td>&lt;.001 (a &lt; b), .03 (a &lt; c)</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Practice perceptions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Awareness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much have you read the oral hygiene policy/guideline for your unit? ((1 = \text{not at all}, 2 = \text{some sections}, 3 = \text{all sections at least once}, 4 = \text{all sections multiple times}))</td>
<td>2.57</td>
<td>2.56</td>
<td>2.85</td>
<td>2.29</td>
<td>.01 (a &lt; b), .03 (a &gt; c), &lt;.001 (b &gt; c)</td>
<td>.17</td>
</tr>
<tr>
<td><strong>Priority</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How do you rate the priority level of oral hygiene for mechanically ventilated patients? ((1 = \text{low}, 2 = \text{moderate}, 3 = \text{high}, 4 = \text{highest}))</td>
<td>2.93</td>
<td>2.88</td>
<td>3.08</td>
<td>2.95</td>
<td>.02 (a &lt; b)</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Attitudes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Agreement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I agree with the oral hygiene guideline/policy. ((1 = \text{not true}, 2 = \text{slightly true}, 3 = \text{somewhat true}, 4 = \text{true}))</td>
<td>3.79</td>
<td>3.77</td>
<td>3.80</td>
<td>3.83</td>
<td>.68</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Self-efficacy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am confident that I can perform oral hygiene as recommended in the policy/guideline. ((1 = \text{not true}, 2 = \text{slightly true}, 3 = \text{somewhat true}, 4 = \text{true}))</td>
<td>3.82</td>
<td>3.78</td>
<td>3.86</td>
<td>3.89</td>
<td>.09</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>Outcome expectancy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using the oral hygiene guideline/policy will reduce VAP ((1 = \text{not true}, 2 = \text{slightly true}, 3 = \text{somewhat true}, 4 = \text{true}))</td>
<td>3.78</td>
<td>3.72</td>
<td>3.65</td>
<td>3.95</td>
<td>.002 (a &lt; c)</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Intention</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I plan to use the oral hygiene guideline/policy whenever I can. ((1 = \text{not true}, 2 = \text{slightly true}, 3 = \text{somewhat true}, 4 = \text{true}))</td>
<td>3.78</td>
<td>3.79</td>
<td>3.76</td>
<td>3.79</td>
<td>.91</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Abbreviations: NA, not applicable; VAP, ventilator-associated pneumonia.

\(^a\) Analysis of variance.

\(^b\) Spearman correlations, all \(P < .001\).
of their daily responsibility to determine appropriate interventions for patients. Improved accessibility and ability to incorporate components of the nursing policy into routine practices may be beneficial. Information bulletins are often easily accessible but provide very brief directions for oral hygiene such as “toothbrush every 4-6 hours.” Thus patients may receive toothbrushing, but other oral hygiene interventions are likely to vary depending on who the nurse is on a certain shift. Without specific directions on practice, oral hygiene practices may be outdated or less prioritized.

**Nursing policies were more comprehensive than order sets or information bulletins.**

Further studies may be needed to explore factors that may encourage toothbrushing such as availability of time and supplies, collaboration with other professions, and factors related to patients. Most of the institutional guidelines for oral hygiene included toothbrushing and swabbing. Oral assessment was included in only 2 hospitals. As recommendations do influence practice for oral assessment, it is suggested that oral assessment be included as part of oral hygiene recommendations.

**Oral Hygiene Practices**

Similar to other study findings, nurses assessed and swabbed patients’ oral cavity more often at hospitals where oral hygiene guidelines specified practice frequency. However, although oral swabbing may provide comfort, it is not as effective as toothbrushing for removing plaque. Toothbrushing was practiced more frequently in our study with 22% to 24% of nurses brushing patients’ teeth every 2 to 4 hours, compared with previous studies where only 5% to 16% of nurses brushed their patients’ teeth every 4 hours. Surprisingly, we found that institutional guidelines were not associated with how often nurses practiced toothbrushing. Furthermore, 10% to 20% of nurses in this study reported brushing their patients’ teeth less than once a shift, indicating room for improvement.

**Institutional Oral Hygiene Guidelines and Factors Associated With Adherence**

A gap exists between the care that patients receive and the evidence for best practice. Yet, we have not identified the optimal processes to translate knowledge into practice. Determining key messages and effective means of communicating are vital. We found that institutional oral hygiene guidelines were disseminated through various methods such as nursing policies, order sets, and informational bulletins. Gurses et al reported that ambiguities surrounding practice recommendations hinder consistent compliance with the guideline recommendations. We found that nursing policies were most detailed and left the fewest ambiguities related to tasks, responsibilities, methods, and expectations of oral hygiene. However, access to more information was not associated with better practice perceptions or adherence. Thus, rather than communicating specific details, identifying essential practice directions such as frequency and effective ways to disseminate this information may be beneficial.

Another approach to effectively translate knowledge into practice is using the electronic health record. Detailed nursing policies provide valuable knowledge but may be difficult to incorporate into daily workflow. An advantage of electronic patient record systems is their capacity to deliver information in a timely manner. Instead of going out of the way to search for nursing policy, which may be stored with other nursing references, having the information in the patient’s electronic health record will aid nurses in obtaining needed information without deviating from daily workflow. Another advantage of electronic systems is the feasibility of updating information as new data become available.

This study had several limitations. This study was cross-sectional; thus, no causal relationship can be identified. Generalizability of the study’s results is limited by its nonrandom sampling, the 45% response rate, and the lack of data on nonrespondents. The survey instrument must be improved in future studies in order to measure oral hygiene practices and perceptions more comprehensively. Despite the limitations, this study did provide new insights such as how the content and delivery method of institutional recommendations affected clinical practices and practice perceptions. Mechanisms such as the electronic health record, which can grant immediate and direct access to information at the point of care, will be one approach.

**Conclusions**

As oral hygiene practices continue to evolve, institutional guidelines will continue to play a critical role in providing directions for clinical practice. The content and dissemination method of institutional guidelines should be carefully considered to encourage more favorable attitudes and behaviors toward the uptake of the recommendations. In order for nurses to access practice recommendations in a timely manner and use them regularly, the guidelines should highlight key messages and should be effectively presented in a way that aligns with the daily workflow of nurses. The electronic health record provides one avenue to realize this. Future studies examining how institutional guidelines could best be incorporated into routine workflow are needed.
FINANCIAL DISCLOSURES
Hiroko Kiyoshi-Teo was supported by the Agency for Healthcare Research and Quality, Ruth L. Kirshstein Research Service Award (F31HS018879-01). This study was funded by Sigma Theta Tau International Honor Society of Nursing, Alpha Eta Chapter, Research Award, and University of California San Francisco School of Nursing Century Club Research Award.

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CLINICAL INDICATORS FOR ENDOTRACHEAL SUCTIONING IN ADULT PATIENTS RECEIVING MECHANICAL VENTILATION

By Mary Lou Sole, RN, PhD, CCNS, Melody Bennett, RN, MN, CCRN, and Suzanne Ashworth, RN, MSN, CCRN, CCNS

Background
Critically ill patients who need mechanical ventilation require endotracheal suctioning. Guidelines recommend coarse crackles over the trachea and/or the presence of a sawtooth pattern on the flow-volume loop of the ventilator waveform as the best indicators.

Objective
To determine clinical cues for endotracheal suctioning in patients who require mechanical ventilation.

Methods
A descriptive study of 42 adult patients receiving mechanical ventilation. After baseline endotracheal suctioning with a closed-system device, patients were assessed hourly up to 4 hours for guideline-based cues for endotracheal suctioning and lung sounds were auscultated. Endotracheal suctioning was done when cues were detected or 4 hours after baseline suctioning. Secretions were collected, measured, and weighed.

Results
Most patients were male (62%) and white (93%). Mean age was 51 years, and mean duration of mechanical ventilation was 7.5 days. The median time to endotracheal suctioning was 2 hours, and a mean of 4.4 mL of secretions was removed. Three patients had no cues identified but had 1.0 mL or more of secretions. The most frequent cues were crackles over the trachea (88%), sawtooth waveform (33%), coughing (29%), and visible secretions (5%). Cues resolved and physiological parameters improved after suctioning. Coarse lung sounds did not improve.

Conclusions
Patients receiving mechanical ventilation should be routinely assessed for coarse crackles over the trachea, the most common indicator for endotracheal suctioning. Despite common practice, assessment of lung sounds to identify the need for suctioning is not supported. (American Journal of Critical Care. 2015;24:318-325)
Critically ill patients treated with mechanical ventilation require an artificial airway, either an endotracheal tube or a tracheostomy tube. These patients often retain tracheobronchial secretions because of impaired cough reflex, decreased mucociliary clearance, and, possibly, increased mucus production. Endotracheal suctioning is essential to remove retained tracheobronchial secretions, and nurses and respiratory care practitioners assume the responsibility for removal. The 2010 clinical practice guidelines1 for endotracheal suctioning of the American Association of Respiratory Care specify that endotracheal suctioning should be done when clinically indicated rather than routinely and give 10 indicators for the suctioning (Table 1).

The sawtooth waveform and coarse crackles over the trachea reportedly are the most sensitive indicators of the need for suctioning.2 Yet in practice, most health care providers rely on auscultation of lung sounds (rather than tracheal sounds) to assess the need for, and response to, endotracheal suctioning. Therefore, the purpose of this study was to identify which assessments best indicate the need for endotracheal suctioning.

**Background**

Although endotracheal suctioning is essential, it should be done only as needed because the procedure can result in hypoxemia, dysrhythmias, or damage of the tracheal mucosa.2,3 Indications for endotracheal suctioning have been studied by only a few researchers. In 1976, Amborn4 published the results of an assessment of 22 clinical signs that might indicate the presence of secretions, which were defined as a volume of secretions 0.5 mL or greater obtained via open suctioning methods 1 hour after a baseline suctioning procedure. The volume of secretions retrieved ranged from 0.0 mL to 5.5 mL. After preliminary analysis, Amborn narrowed the signs to 15 (including increased body temperature; increases or decreases in pulse, respiratory rate, systolic blood pressure, diastolic blood pressure, ventilator system pressure, or tidal volume; coarse breath sounds; and prolonged expiratory sounds). She found that a change of 5 mm Hg in systolic or diastolic blood pressure was a significant predictor of secretions ($P = .02-.07$). She also reported that the number of signs present was associated with the volume of secretions.

The presence of a sawtooth pattern on ventilator waveform recordings was first reported in 1994 by Jubran and Tobin.5 In a sample of 50 ventilator-dependent patients with a tracheostomy, a sawtooth waveform on the flow-volume loop (observed via an external apparatus) had high sensitivity (0.76-0.86) and specificity (0.86-0.90) for detection of secretions during a 1-minute period of spontaneous breathing.

Guglielminotti et al6 conducted a follow-up study to identify factors indicative of retained secretions and the need for endotracheal suctioning in patients receiving mechanical ventilation. Need for suctioning was defined as retrieval of 0.5 mL or more of secretions during suctioning. A sawtooth pattern on the flow-volume loop waveform together with coarse crackles over the trachea were the best indicators of retained secretions. Guglielminotti et al

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**Table 1**

Recommendations for endotracheal suctioning from the American Association of Respiratory Care

<table>
<thead>
<tr>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawtooth pattern on flow-volume loop on ventilator monitor</td>
</tr>
<tr>
<td>Coarse crackles auscultated over trachea</td>
</tr>
<tr>
<td>Increased peak inspiratory pressure during volume control ventilation</td>
</tr>
<tr>
<td>Decreased tidal volume during pressure-controlled ventilation</td>
</tr>
<tr>
<td>Deterioration in oxygen saturation and/or arterial blood gas values</td>
</tr>
<tr>
<td>Visible secretions in airway</td>
</tr>
<tr>
<td>Patient’s inability to generate an effective cough</td>
</tr>
<tr>
<td>Acute respiratory distress</td>
</tr>
<tr>
<td>Suspected aspiration of gastric or upper airway secretions</td>
</tr>
</tbody>
</table>

\*Based on information from the clinical practice guidelines from the American Association of Respiratory Care.1

---

**About the Authors**

Mary Lou Sole is Orlando Health Distinguished Professor and Pegasus Professor, University of Central Florida, College of Nursing, Orlando, Florida, and a research scientist at Orlando Health, Orlando, Florida. Melody Bennett is a member of the adjunct faculty at the University of Central Florida and a clinical research coordinator at Orlando Health. Suzanne Ashworth is a clinical nurse specialist in neurological critical care at Orlando Regional Medical Center, Orlando, Florida.

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also concluded that the absence of a sawtooth pattern on the ventilator flow-volume loop waveform can be used to rule out retained secretions.

Wood\textsuperscript{c} conducted a study to identify differences in the outcomes of endotracheal suctioning between patients who had routine (every 2 hours) suctioning and those who had suctioning based on the results of nurses’ assessments. Endotracheal suctioning was done every 2.6 hours in the assessment group and every 2.1 hours in the routine group. Compared with patients in the routine group, patients in the assessment group had significantly more secretions retrieved per suctioning episode and a greater reduction in peak airway pressure after the procedure. Assessment indicators most often used by the nurses were chest sounds (crackles, gurgles, and wheezes) detected via auscultation and coughing. Other clinical indicators were recorded in documentation notes (oxygen desaturation, changes in arterial blood gases, and increased peak airway pressure), but these cues were not used by the nurses to determine the need for endotracheal suctioning.\textsuperscript{6} A limitation of Wood’s study\textsuperscript{c} is that neither auscultation over the trachea nor inspection of ventilator waveforms was included in the nursing assessment. Additionally, no minimum amount of secretions was defined as indicating the need for suctioning. Higher secretion volumes in the assessment group compared with the routine group may have been due to the longer time between suctioning episodes in the assessment group.

Endotracheal suctioning may also improve outcomes or reduce complications, such as ventilator-associated pneumonia. Caruso et al\textsuperscript{7} found that routine suctioning based on indications described in the guidelines\textsuperscript{1} of the American Association of Respiratory Care, along with instillation of physiological saline, reduced the risk for ventilator-associated pneumonia by 54% in a sample of critically ill patients. The authors\textsuperscript{7} hypothesized that suctioning and/or coughing induced after the instillation of physiological saline may have contributed to the reduced risk for infection. Blamoun et al\textsuperscript{8} included regular endotracheal suctioning, defined as suctioning every 4 hours, as part of an expanded ventilator bundle and were successful in reducing the rates of ventilator-associated pneumonia to zero. However, which intervention contributed to the reduction in the rate of pneumonia is not known.

Sole and Bennett\textsuperscript{9} assessed the practices of nurses and respiratory care practitioners regarding endotracheal suctioning. A total of 85 participants in the study, mostly experienced providers, listed assessments the participants used to determine the need for endotracheal suctioning. The 2 most frequent responses were an increase in peak inspiratory pressure or an alarm indicating an increase (69%) and detection of rhonchi over the lung fields via auscultation (66%). Only 14% listed a sawtooth pattern on the respiratory waveform as an indicator, and no one listed detection of coarse crackles over the trachea via auscultation. Generalizability of the results were limited because all the responses were from experienced providers in a single hospital system.\textsuperscript{9}

Endotracheal suctioning is considered a necessary procedure for patients with artificial airways. Recommendations for identifying the need for endotracheal suctioning have been developed by professional societies\textsuperscript{1} but may not be widely incorporated. In clinical practice, a variety of assessments are used to determine the need for suctioning, primarily auscultation for detection of abnormal sounds. The purpose of this study was to expand on the work of others\textsuperscript{2,4,6,9} to help determine the best practices for assessing the need for endotracheal suctioning.

**Methods**

**Design**

A descriptive, comparative study design was used. The study was approved by the appropriate institutional review boards of the hospital and university. Each patient’s legal proxy provided consent for the patient’s participation in the study.

**Setting and Sample**

The study was conducted in the critical care units (medical-surgical, trauma, and neurological) at a tertiary care hospital in the Southeastern United States. A convenience sample of patients receiving mechanical ventilation was recruited for participation. Patients were included in the study if they were adults (18 years or older) who were treated with traditional mechanical ventilation with a ventilator waveform display available. The target sample size was 66 patients to compare the study findings with those of Guglielminotti et al.\textsuperscript{2} However, the study was ended after 43 patients because of consistent patterns noted during data collection.

**Procedures**

Demographic data were obtained from the electronic medical records. After a patient was enrolled in the study, baseline suctioning was done with the closed-system suction device after hyperoxegenation with 100% oxygen via the ventilator. Immediately before and after the baseline suctioning, physiological

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**Patients suctioned on the basis of assessment rather than routine had more secretions retrieved.**
Data were recorded from bedside monitors and the ventilator and digital photographs of the ventilator waveform were obtained.

After baseline suctioning, each patient was assessed every hour by 1 of 2 investigators (M.L.S. or M.B.) by using a checklist derived from the American Association for Respiratory Care guidelines. Tracheal auscultation was done above the sternum, and the presence or absence of coarse crackles was noted during the expiratory phase of ventilation. Lung sounds were also assessed via auscultation because that practice is common. Interrater reliability was established between investigators during simultaneous assessment of 5 patients. The ventilator waveforms routinely monitored were the scalars for flow, volume, and pressure rather than the flow-volume loop. Because the flow-time scalar waveform is commonly used in practice and can be used to identify obstruction to flow in the airways, this waveform was used for detection of a sawtooth pattern. Physiological data and digital photographs of the ventilator waveform tracings were obtained hourly. When an indication for endotracheal suctioning per the checklist was identified, suctioning via a closed-system device was performed. Suctioning passes were repeated until the investigator deemed that secretions were retrieved. Physiological data, peak inspiratory pressure, and waveform images were recorded before and after the suctioning. Additionally, secretions obtained during endotracheal suctioning were weighed and measured. If no cues were identified within 4 hours after the baseline suctioning, endotracheal suctioning was performed and volume and weight of the secretions was recorded. The photographs of the respiratory waveforms were reviewed independently by 3 investigators to determine the presence or absence of a sawtooth pattern, a pattern similar to that seen in atrial flutter cardiac rhythms. A sawtooth pattern was deemed present when all investigators agreed on its identification on the image. Figures 1A and 2 show the presence of a sawtooth pattern, which is especially prominent in Figure 2.

Results

Demographic Data

A total of 43 patients were enrolled in the study between June and December 2012. One patient was extubated during data collection and so the patient's data were excluded from analysis, yielding a final sample size of 42. Most of the patients were male (62%), were white (93%), and had an admitting diagnosis of trauma (60%). Mean age was 51 (SD, 21) years, and the mean duration of mechanical ventilation was 7.5 (SD, 6.1) days. The majority of patients (83%) had volume synchronized intermittent mandatory ventilation; others were on assist-control (10%) or pressure support (7%) ventilation. Median ventilator settings included tidal volume 700 mL, set respiratory rate 2/min, positive end-expiratory pressure 5 cm H₂O, pressure support 10 cm H₂O, and fraction of inspired oxygen 0.35. The median score on the Glasgow Coma Scale was 10, and the median score on the Sedation Agitation Scale was 3. Among the patients, 52% had a heat-moist exchanger for humidification, and 48% had a heated circuit.
Suctioning Data

The median time to endotracheal suctioning was 2 hours (range, 1-4 hours). A total of 2 to 4 suctioning passes were needed to clear secretions; the mean was 2.5 (SD, 0.6) passes, and the median was 2.0. The volume of secretions ranged from 1.0 to 15.0 mL; mean volume was 4.4 (SD, 3.2) mL, and the median was 3.5 mL. The mean weight of secretions was 3.3 (SD, 3.1) g, with a median of 2.6 g. The correlation between secretion volume and weight was 0.93 ($P = .01$).

Suctioning Cues

Cues indicating the need for endotracheal suctioning were identified in 93% of patients. A total of 37 patients (88%) had coarse crackles over the trachea, 14 (33%) had a sawtooth pattern on the flow-time waveform, 12 had coughing (29%), and 2 (5%) had visible secretions.

A total of 7% of the sample had no identified cues, 45% had 1 cue, 33% had 2 cues, 12% had 3 cues, and 2% had 4 cues. Mean volume of mucus by the number of cues identified was compared by using analysis of variance. Although not significant ($P = .17$), the volume of secretions was associated with the number of cues: 0 cues with 3 mL, 1 cue with 3.8 mL, and 2 or more cues with 5.6 mL.

Improvement After Suctioning

Repeated-measures statistics were used to assess for improvement after suctioning. A paired-sample $t$ test was used to assess physiological characteristics before and after suctioning. Peak inspiratory pressure was lower and oxygen saturation was increased after suctioning (Table 2). A related sample McNemar test was used to compare presence or absence of cues before and after suctioning. After suctioning, absence of a sawtooth waveform ($P < .001$; Figure 1B), no crackles over the trachea ($P < .001$), and no cough ($P < .001$) were noted, indicating removal of secretions. No difference was noted in visible secretions before or after suctioning ($P = .50$). Lung sounds did not improve after suctioning. Both before and after suctioning, 45% of the patients had rhonchi, coarse lung sounds, or both ($P > .99$).

### Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before suction</th>
<th>After suction</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak inspiratory pressure, cm H$_2$O</td>
<td>23.2</td>
<td>21.8</td>
<td>.001</td>
</tr>
<tr>
<td>Oxygen saturation, %</td>
<td>95.3</td>
<td>96.7</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*a Mandatory breath for those on synchronized intermittent mandatory ventilation or assist-control ventilation only (n=31).*

**Additional Findings**

Because 3 patients had no cues, demographic data and volume of mucus between patients with and without cues were compared. Nonparametric statistics indicated no significant differences across demographic variables.

An independent-samples $t$ test was used to compare volume of mucus retrieved with the type of ventilator humidification. The 20 patients who had a heated circuit had 4.8 mL of mucus retrieved, whereas the 22 patients who had a heat-moisture exchanger had 4.2 mL retrieved ($P = .56$). Additionally, the percentage of patients with a sawtooth pattern did not differ according to type of humidification. A sawtooth pattern was detected in 30% of the patients with a heated circuit and in 36% of the patients with a heat-moisture exchanger ($\chi^2$ analysis: $P = .66$).

**Discussion**

Suctioning was indicated a median of 2 hours after the baseline suctioning. This finding agrees with the results of Guglielminotti et al.² All of our patients, including the 3 who had no assessment cues, had 1.0 mL or more of secretions suctioned. This threshold was higher than that set by Amborn,⁴ Jubran and Tobin,⁵ and Guglielminotti et al.² who used a threshold of 0.5 mL or greater. We chose the 1-mL value because measuring smaller amounts in the specimen traps was difficult. We found that weight of secretions can be used as a proxy for volume (we found a high correlation between volume and weight) as reported previously.¹¹

Mean volume of secretions was higher in our patients than in the patients of Guglielminotti et al.² We did not use suctioning until cues were identified, a practice that may account for the higher volume of secretions. Wood⁶ found a higher volume of secretions when suctioning was done on the basis of nurses’ assessments rather than routinely. Our patients received mechanical ventilation for a mean of 7.5 days, compared with 4.6 days for the patients in the study by Guglielminotti et al., and had humidification of the ventilator circuit. Either of these factors could have been a reason for our higher volume of secretions.

We detected coarse crackles over the trachea in 88% of our patients, a higher percentage than the 67% reported by Guglielminotti et al.² The larger volumes of secretions retrieved in our patients may be a cause for the increase in the number of patients with audible crackles over the trachea.

We identified a sawtooth pattern on the ventilator waveform in only 33% of our patients, whereas
Guglielminotti et al detected a sawtooth pattern in 88%. Perhaps the flow-time waveform is not as sensitive as the flow-volume loop waveform for detecting this pattern. However, we wanted to use standards of care for respiratory monitoring in force at the clinical site so that the findings could be applied in practice; therefore, we used the flow-time waveform for assessment. We found no differences in sawtooth patterns between type of humidification.

Our patients were receiving mechanical ventilation via 3 different ventilators: Avea (CareFusion), Bear 1000 (CareFusion), and Evita (Draeger). Waveforms were slightly different on each type (Figure 2). The Avea ventilator had the clearest waveforms for visualization and assessment. We classified a pattern as sawtooth only if it clearly showed oscillations (Figure 1A and Figure 2). Many patients had a wavy waveform (Figure 1B). We did not classify this pattern as a sawtooth. Although we attempted to empty moisture from the ventilator circuit, small amounts of water could result in a wavy flow-time waveform (Figure 1B).

Additionally, our patients differed from those in other studies. Compared with our patients, the patients in the study of Guglielminotti et al were older, predominately had respiratory failure, and had been receiving mechanical ventilation for a shorter time. Our patients were younger trauma patients who had been receiving mechanical ventilation for a longer period. Although our patients had stable ventilator settings, they had respiratory failure that required prolonged mechanical ventilation. Their physiological conditions may have resulted in greater production of secretions.

Similar to the results of Wood, improvements in peak inspiratory pressure and oxygen saturation occurred with suctioning. Although statistically significant, the changes were small and may not be important clinically. However, our results show the impact of suctioning on physiological parameters.

Although our findings were not statistically significant, we found that the volume of secretions increased with the number of cues identified. This finding compares favorably with results reported by Amborn, who noted that the number of signs (although different from ours) was associated with secretion volume. Wood also found a higher volume of mucus when suctioning was done according to the results of nurses’ assessments.

Despite common practice, assessment of lung sounds is not a good method for detecting a need for suctioning. Nearly half of our patients had rhonchi or coarse breath sounds over the lung fields both before and after suctioning. Endotracheal suctioning retrieves secretions primarily from the upper part of the airway above the carina. Secretions in the lower parts of the airway that may result in coarse breath sounds are not retrieved. Therefore, despite common practice, breath sounds would not necessarily improve after suctioning.

Our study had limitations. Patients received mechanical ventilation via 3 different ventilators with different quality and depiction of waveforms, and we looked solely at the flow-time scalar. Comparing simultaneous tracings of the flow-time scalar and the flow-volume loop waveforms for presence of a sawtooth pattern would also be important. Ventilation modes and humidification varied; a more homogeneous group of patients might yield better data to guide practice. Our patients had been intubated for a mean of more than a week. Findings might be different in patients who were intubated for only a few days compared with findings in patients who had refractory respiratory failure or lung injury that requires a longer duration of mechanical ventilation. Studying patients over the course of mechanical ventilation would yield rich data. None of our patients were given paralytic medications. Patients treated with paralytic agents are an important group to study because they might not have some cues, such as coughing.

Additional research is needed to identify the optimal frequency of assessments to guide suctioning. Data are also needed to determine the optimal timing for suctioning when no cues are detected.

Because patients should receive suctioning only when needed in order to prevent complications from the procedure, the right assessments must be done to determine the need for suctioning. On the basis of our data, we recommend incorporating assessment of the ventilator waveform and auscultation over the trachea as part of the assessment for suctioning done every 2 to 4 hours. The presence of a sawtooth pattern on a patient’s flow-time waveform should alert a nurse or respiratory care practitioner to further assess the patient for the need for suctioning. The patient should also be assessed for physiological changes, such as high-pressure alarms, cough, and visible secretions. Not all ventilators have a display of the waveform; therefore, assessments that rely on readily available data are just as important as those that rely on technology. Additionally, nurses generally rely on respiratory care practitioners to manage the ventilator and may need some basic knowledge of waveform analysis.

FINANCIAL DISCLOSURES
None reported.
REFERENCES


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1. Which of the following best describes the correct location and ventilation phase for performing tracheal auscultation to assess a patient’s need for endotracheal suctioning?
   a. Just below the carina, during inspiratory phase
   b. Just below the carina, during expiratory phase
   c. Above the sternum, during inspiratory phase
   d. Above the sternum, during expiratory phase

2. In this study, a sawtooth pattern on the ventilator waveforms was deemed to be present when which of the following occurred?
   a. Three of the study’s investigators identified the pattern on the waveform image.
   b. One or more of the study’s investigators identified the pattern on the waveform image.
   c. The flow-volume scalar waveform image showed a pattern consistent with presence of secretions.
   d. The pressure-volume scalar waveform image showed a pattern consistent with obstruction to airway flow.

3. This study’s results confirmed which of the following assessment cues as an indicator of the need for endotracheal suctioning?
   a. A change of 5 mm Hg in systolic or diastolic blood pressure
   b. A sawtooth waveform on the flow-time waveform
   c. Low arterial oxygen saturation
   d. Decreased tidal volume during pressure-controlled ventilation

4. Based on the findings of this study, which of the following statements regarding the volume of mucus retrieved during endotracheal suctioning is true?
   a. The volume of mucus retrieved during frequent suctioning is expected to be higher than the volume of mucus obtained following suctioning that is done less frequently.
   b. The volume of mucus retrieved during suctioning is expected to be higher if physiological saline is instilled prior to suctioning.
   c. The volume of mucus retrieved during suctioning is expected to be higher when suctioning is done on the basis of nurses’ assessments rather than being done routinely.
   d. The volume of mucus retrieved during suctioning is expected to be less than 0.5 mL in patients with assessment cues indicating suctioning is needed.

5. According to research about clinical indicators of the need for endotracheal suctioning in patients being treated with mechanical ventilation, which of the following can be used to rule out retained secretions?
   a. Absence of coarse crackles over the trachea
   b. Absence of a sawtooth pattern on the ventilator flow-volume loop waveform
   c. No difference in visible secretions before and after suctioning
   d. No difference in lung sounds before and after suctioning

6. Which of these reasons best explains why assessment of lung sounds via auscultation was included as a clinical indicator in this study?
   a. Because the practice of lung auscultation is common among nurses
   b. Because performance of this skill during simultaneous assessment of 5 patients established interrater reliability among study investigators
   c. Because competency with lung auscultation is more easily established than competency with tracheal auscultation
   d. Because one purpose of the study was demonstration of the lack of reliability of this practice

7. During the study, endotracheal suctioning passes were repeated until which of the following occurred?
   a. A maximum of 1.0 mL of mucus was obtained
   b. The patient’s oxygen saturation level increased
   c. A maximum of 5 passes were made
   d. The investigator deemed secretions were retrieved

8. Which of the following is the most likely cause of the increased volume of secretions in patients in this study as compared to those in a similar study done by Guglielminotti et al?
   a. The ventilator circuits of this study’s patients were humidified.
   b. Patients in this study were suctioned more frequently.
   c. The measurement of small mucus volumes was less accurate in this study.
   d. Different ventilation modes were used in this study.

9. Which of the following was the reason for ending the study after obtaining data from only 43 patients instead of 66 patients as planned originally?
   a. The remaining patients in the original sample were extubated during data collection.
   b. Consistent patterns were noted during data collection from the first 43 patients.
   c. Investigators realized their patient group was too homogenous to yield data of sufficient quality to guide practice.
   d. Investigators realized their patient group was not homogenous enough to yield data of sufficient quality to guide practice.

10. Based on the findings of this study, which of the following outcomes would be most likely to result from administration of paralytic medications to a patient being treated with mechanical ventilation?
    a. Increased tidal volume during pressure-controlled ventilation
    b. Aspiration of gastric or upper airway secretions
    c. Decreased peak inspiratory and expiratory pressures
    d. Increased retention of tracheobronchial secretions

11. Which of the following factors was specifically suggested by investigators as a possible reason for the greater production of secretions by patients in this study?
    a. Their median score of 10 on the Glasgow Coma Scale
    b. The use of volume synchronized intermittent mandatory ventilation mode
    c. Their physiological conditions
    d. Their median score of 3 on the Sedation Agitation Scale

12. Which of the following is recommended by the investigators on the basis of data obtained from this study?
    a. Suctioning should be done every 4 hours in patients when no clinical cues are detected.
    b. Suctioning should not be done routinely in patients in whom no clinical cues are detected.
    c. Assessment of the need for suctioning should be done every 1 to 2 hours.
    d. Assessment of the need for suctioning should be done every 2 to 4 hours.

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Endotracheal suctioning (ET) for patients receiving mechanical ventilation is routinely done in the acute care setting. Practice over time has varied from suctioning done at routine intervals with the instillation of normal saline along with checking breath sounds before and after suctioning to assess for improvement, to suctioning only when a clinician-based assessment indicates need.

However, only recently have guidelines have been published that can assist both nurses and respiratory therapists in using evidence-based clinical cues for patient assessments. In their recent study, Sole and colleagues demonstrated that these recommendations could be appropriately applied in the clinical practice environment to improve assessment of need for and adequacy of suctioning. They found that auscultation of coarse crackles over the trachea was the most common indicator for ET suctioning and, further, that assessment of lung sounds to identify the need for suctioning is not recommended.

Here’s what you can do:

• Survey the nursing and respiratory therapy staff about assessments used to indicate the need for suctioning.
• Establish what the current practice is on your unit.
• Have an interdisciplinary team review your current practice protocol for suctioning, and update it to include established guidelines.
• Validate that your documentation protocols are consistent with any changes in your practice protocols.
• Establish a process of peer-review for competencies related to suctioning for a patient being treated with mechanical ventilation.
• Disseminate updates to practice protocols in communication with the interdisciplinary team.

Other helpful resources:

• Burns SM, ed. AACN Protocols for Practice: Care of Mechanically Ventilated Patients. 2nd ed. Sudbury, MA: Jones and Bartlett Publishers; 2007.

REFERENCES


©2015 American Association of Critical-Care Nurses
doi: http://dx.doi.org/10.4037/ajcc2015597

Based on material from and published as a supplement to the article by Sole, et al, “Clinical Indicators for Endotracheal Suctioning in Adult Patients Receiving Mechanical Ventilation” (American Journal of Critical Care. 2015;24:318-325).
SCORING SYSTEMS FOR OUTCOME PREDICTION IN A CARDIAC SURGICAL INTENSIVE CARE UNIT: A COMPARATIVE STUDY

Themistocles Exarchopoulos, RN, MSc, Efstratia Charitidou, MSc, Panagiotis Dedeilias, MD, Christos Charitos, MD, Christina Routsi, MD

BACKGROUND
Most scoring systems used to predict clinical outcome in critical care were not designed for application in cardiac surgery patients.

OBJECTIVES
To compare the predictive ability of the most widely used scoring systems (Acute Physiology and Chronic Health Evaluation [APACHE] II, Simplified Acute Physiology Score [SAPS] II, and Sequential Organ Failure Assessment [SOFA]) and of 2 specialized systems (European System for Cardiac Operative Risk Evaluation [EuroSCORE] II and the cardiac surgery score [CASUS]) for clinical outcome in patients after cardiac surgery.

METHODS
Consecutive patients admitted to a cardiac surgical intensive care unit (CSICU) were prospectively studied. Data on the preoperative condition, intraoperative parameters, and postoperative course were collected. EuroSCORE II, CASUS, and scores from 3 general severity-scoring systems (APACHE II, SAPS II, and SOFA) were calculated on the first postoperative day. Clinical outcome was defined as 30-day mortality and in-hospital morbidity.

RESULTS
A total of 150 patients were included. Thirty-day mortality was 6%. CASUS was superior in outcome prediction, both in relation to discrimination (area under curve, 0.89) and calibration (Brier score = 0.043, $\chi^2 = 2.2$, $P = .09$), followed by EuroSCORE II for 30-day mortality (area under curve, 0.87) and SOFA for morbidity ($\rho = 0.37$ and 0.35 for the CSICU length of stay and duration of mechanical ventilation, respectively; Wilcoxon $W = 367.5$, $P = .03$ for probability of readmission to CSICU).

CONCLUSIONS
CASUS can be recommended as the most reliable and beneficial option for benchmarking and risk stratification in cardiac surgery patients. (American Journal of Critical Care. 2015;24:327-335)
Scoring systems were introduced in both research and clinical practice of intensive care units (ICUs) in order to provide a reliable tool for objectively assessing severity of acute illness in critically ill patients, for better profiling of patients’ risk of mortality, and for improved group stratification and analysis. Most of the scoring systems that are currently in use were initially validated in general ICU populations and not in special units or subgroups of patients. Specifically, cardiac surgery patients have been excluded from the development studies of general predictive scoring systems. Cardiac surgical ICUs (CSICUs) serve a specific population of patients. The acute pathophysiological consequences of cardiopulmonary bypass (CPB), although transient, influence the values of the variables used by the general scoring systems during the early postoperative course.1,2 Moreover, several pathophysiological changes may be obscured by the influence of system support devices, such as intra-aortic balloon pumps, ventricular assist devices, hemofiltration, and mechanical ventilation.1-9

Nevertheless, several of the general scoring systems have been subsequently validated and are currently in use in CSICUs, owing to the lack of a suitable and qualified system for this specific population. The most established are the Acute Physiology and Chronic Health Evaluation (APACHE) II,10 the Simplified Acute Physiology Score (SAPS) II,11 and the Sequential Organ Failure Assessment (SOFA),12 with a good reported performance. Originally published in 1999, the European System for Cardiac Operative Risk Evaluation (EuroSCORE), a model for predicting operative mortality following open heart surgery, is based on a large database.13 It recently has been updated as EuroSCORE II,14 in order to enhance the performance of the model so as to maintain and optimize its usefulness in contemporary cardiac surgery practice. However, EuroSCORE is limited to preoperative variables and does not take into account intraoperative or postoperative circumstances. Finally, in 2005, the cardiac surgery score (CASUS),9 specifically for cardiac surgery patients, was developed in order to fill this gap. CASUS has been constructed and validated in a large prospective study in Germany; however, it is not yet widely used. Possible different populations of patients, surgical procedures, and postoperative handling may influence the predictive ability of a scoring system.

We hypothesized that CASUS would perform better than the other scoring systems (even outside of Germany, where it had proven successful), since it was designed to specifically target the peculiarities of cardiac surgery patients. To this end, we conducted the present study to assess and compare the capacity and reliability of CASUS and the recently updated EuroSCORE II as well as the general scoring systems APACHE II, SAPS II, and SOFA for predicting the clinical outcome of patients undergoing open heart surgery in our hospital.

Methods
Study Design and Setting
We conducted a single-center prospective cohort study. All consecutive admissions in the CSICU of Evangelismos Hospital, an 1100-bed, tertiary-care institution, between February 15, 2012, and May 15, 2012, were included in the study. In this 8-bed CSICU, the mean number of new admissions was approximately 3 patients per day for each year.

Patients
Our sample comprised all adult patients who underwent open heart surgery during the study period. Patients were transferred from the operating room directly to the CSICU, where they remained for postoperative monitoring for at least 24 hours; then they were stepped down to the general care area in order to be discharged from the hospital. More specific exclusion criteria were not applied. Data on preoperative condition, intraoperative parameters, and postoperative course were collected daily from each patient. The postoperative scores.
were calculated by using the most abnormal value for each variable during the first postoperative 24 hours in the CSICU. EuroSCORE II was based on the logistic version, whereas the 4 postoperative scoring systems were calculated through additive versions. No data were missing.

Clinical outcome was defined as postoperative morbidity and mortality. Morbidity included the following variables: duration of mechanical ventilation, length of stay in the CSICU and in the hospital’s general care area, readmission to the CSICU, and reintubation. Furthermore, we recorded preoperative and intraoperative parameters to examine the potential statistical correlation with the outcome. Mortality was defined as death within 30 days after surgery (either during hospitalization or after discharge).

For patients readmitted to the CSICU postoperatively, we took into account only the length of the initial stay in the CSICU. In cases of reintubation, we evaluated only the initial duration of mechanical ventilation, in accordance with the rest of the sample.

The study protocol was approved by the scientific council and the bioethics committee of the Evangelismos Hospital (Approval No. 208/01-08-2011). Since it was an observational study and medical confidentiality and personal data were preserved, the requirement for informed consent from each patient or relatives was waived.

Statistical Analyses

Statistical analyses were performed by using R Statistical Software, version 2.15.1 (The R Foundation for Statistical Computing). The level of statistical significance was set at 5% (P < .05). Multiple Kolmogorov-Smirnov tests were applied and indicated that all quantitative variables of the study are not normally distributed (P < .001); therefore, we mainly used nonparametric statistical procedures. Qualitative factors are presented by their absolute (N) and relative (%) frequencies. Quantitative characteristics are presented by their mean and standard deviation (SD) when symmetric and by their median and interquartile range (IQR) when severely skewed. In case of quantitative characteristics, the Wilcoxon test was used; otherwise the P value is associated with the Fisher exact test.

The nonparametric Spearman correlation coefficient was used to measure the correlation between quantitative variables. The nonparametric Wilcoxon test was implemented to investigate a potential statistical association between a quantitative variable and a dichotomous factor. The Fisher exact test was used between qualitative factors.

The discriminating capacity of all scoring systems over 30-day mortality prediction was measured via the receiver operating characteristic (ROC) curves, which illustrate the sensitivity (true-positive cases) against 1 minus the specificity (false-positive cases). In order to examine the potential association of each scoring system with 30-day mortality, univariate logistic regression models were fitted. Various aspects of performance and goodness of fit were assessed by several indices, including the Hosmer-Lemeshow statistic, the Nagelkerke pseudo-

The postoperative scores included the most abnormal value during the first 24 hours in the unit.
on CPB (median [IQR]: CPB time, 131 [56] minutes; aortic cross-clamp time, 82 [46] minutes; circulatory arrest time, 33 [19.7] minutes). Nine patients of this group underwent an on-pump beating-heart technique. The remaining 21 patients underwent surgery without CPB and with the beating-heart technique. There were 10 cases of reintubation (7%) due to weaning failure and 9 cases of readmission to the CSICU (6%) caused by various reasons such as cardiac arrest, hemodynamic or respiratory instability, renal dysfunction, and neurological impairment. The types of surgical procedures that were performed on the sample are shown in Table 2.

### Performance of the Scoring Systems

Figure 1 illustrates the smooth ROC curves concerning the evaluated scoring systems as to 30-day mortality. All curves demonstrate very good discrimination between survivors and nonsurvivors. The area under the ROC curve (AUC) for CASUS was 0.89, greater than those of the other scoring systems; nonetheless, the AUC was high in every case. De Long tests have been conducted in order to compare the differences between AUC pairs (all P values > .05). A summary of the main results is given in Table 3, including details of the ROC analysis and the logistic regression models. Particularly, all scoring systems are significantly associated with the 30-day mortality. CASUS is accompanied by the highest value of Nagelkerke pseudo-$R^2$, whereas EuroSCORE II has the lowest value. OCC is maximized under the SAPS II, but all OCC values are substantially high (> 90%). The value of the Brier score is very close to zero for all scoring systems.
with the lowest values pertaining to CASUS and SAPS II. Finally, the Hosmer-Lemeshow test revealed quite high $P$ values, implying good calibration, with best results (highest $P$ value) concerning CASUS and SAPS II. Therefore, the results from both calibration procedures implemented here seem to coincide.

The correlations among the scoring systems are pictured in the Spearman graphical correlation matrix of Figure 2, where the more intense the positive correlation between 2 variables, the more intense is the shade of grey for the corresponding cell. It is obvious that all the variables are positively correlated. All correlations are statistically significant ($P < .01$). The highest correlation was found between SOFA and CASUS.

**Correlations with Morbidity**

As for predictors of in-hospital morbidity, mortality correlated significantly with the duration of mechanical ventilation, reintubation, and CSICU LOS (Table 1). The nonparametric Wilcoxon test was used to identify potential statistical associations with quantitative characteristics. Only CASUS ($W = 331.5, P = .005$) and APACHE II score ($W = 404.0, P = .02$) are significantly differentiated by the reintubated group of patients, whereas SOFA score ($W = 367.5, P = .03$) and CASUS ($W = 320.5, P = .01$) are significantly differentiated in case of readmission to the CSICU. SAPS II was not correlated with any of the postoperative morbidity factors.

Because most cardiac surgery patients do not experience significant postoperative morbidity, the predictive value of a severity of illness scoring system is inherently limited. Restricting use of this type of predictive system to a population of cardiac surgery patients with complicated postoperative course may add predictive power to the system. EuroSCORE II may be considered a good summary of preoperative and intraoperative risk factors, and SOFA, with its derived variables, may be considered a reliable descriptor of postoperative complications and severity of illness, namely the degree and the progression of postoperative organ dysfunction and failure. We aimed to examine the performance of combined EuroSCORE II with SOFA compared with CASUS. We have modeled the performance of EuroSCORE II and SOFA. The new model (OCC = 88.6%, Brier score = .04, $R^2 = 33.9$%, Hosmer-Lemeshow $P = .79$) does not appear to be overall better than CASUS.

**Discussion**

In this study, we evaluated and compared the accuracy of 5 scoring systems to predict morbidity and mortality in patients undergoing cardiac surgery. All systems showed an acceptable performance; however, CASUS appeared to be superior to the others for predicting mortality in these patients. This superiority was reflected by an AUC of 0.89. Because CASUS was designed to target cardiac surgery patients specifically, this finding seems plausible and is not unexpected. Despite the fact that several studies have been focused on use of severity scores to predict mortality after cardiac surgery, only a limited number of studies have compared the predictive ability of all the available scoring systems commonly used in both general ICUs and CSICUs.
Our findings are in accordance with results of a recent study in cardiac surgery patients where CASUS was better for discriminating between survivors and nonsurvivors than were other outcome prediction systems, with an AUC of more than 0.90, followed by SOFA, whereas SAPS II and APACHE II did not perform well in terms of calibration and discrimination statistics.

Apart from the systems specialized for cardiac surgery patients, scores from the general prognostic scoring systems have also shown a significant correlation with 30-day mortality and morbidity. Although these scoring systems were not designed for the specific features of open heart surgery, and they had excluded these patients from their initial development studies, the main and most commonly used scoring systems in the field of intensive care, such as the APACHE II, SAPS II, and SOFA, have been evaluated in this specific subset of patients.

In our sample, SOFA exhibited the least satisfactory performance in relation to the prediction of 30-day mortality, something not unforeseen, because the model was originally designed over time to describe the changing severity in the process of organ failure in ICU patients with sepsis; thus, it was designated more as an indicator of morbidity. In 2003, Ceriani et al. examined the use of SOFA scores to predict postoperative morbidity in cardiac surgery patients. That study showed that despite the peculiarities of cardiac surgery, mainly because of the use of CPB, which is an important confounder in evaluating the severity of organ dysfunction, the model was able to describe reliably the evolving course of organ failure after open heart surgery and without any specific adjustments and modifications. Similarly, SOFA score was associated with morbidity in the early postoperative period after cardiac surgery in another study. This conclusion was confirmed.

**Table 3**

Summary of test results for SOFA, CASUS, SAPS II, APACHE II, and EuroSCORE II

<table>
<thead>
<tr>
<th>Test</th>
<th>Preoperative day EuroSCORE II</th>
<th>Day 1 in cardiac surgical intensive care unit</th>
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<tr>
<td></td>
<td>SOFA</td>
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<tr>
<td>Logistic regression</td>
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<tr>
<td>Nagelkerke pseudo-$R^2$, %</td>
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<td>25</td>
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<tr>
<td>Brier score</td>
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<td>0.048</td>
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<tr>
<td>Hosmer-Lemeshow $\chi^2$</td>
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<tr>
<td>P</td>
<td>.42</td>
<td>.57</td>
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</tbody>
</table>

Receiver operating characteristic analysis

| Area under curve | 0.87 | 0.76 | 0.89 | 0.80 | 0.82 |
| 95% CI | 0.74-0.95 | 0.52-0.92 | 0.74-0.97 | 0.60-0.92 | 0.61-0.94 |
| Best cutoff | 4.73 | 7.5 | 8.5 | 43.5 | 22.5 |
| Sensitivity, % | 88.9 | 100.0 | 88.9 | 55.5 | 66.6 |
| Specificity, % | 82.3 | 47.5 | 73.8 | 93.6 | 89.3 |

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; CASUS, cardiac surgery score; EuroSCORE, European System for Cardiac Operative Risk Evaluation; SAPS, Simplified Acute Physiology Score; SOFA, Sequential Organ Failure Assessment.

**Figure 2** Spearman’s graphical correlation matrix among the scoring systems: cardiac surgery score (CASUS), Sequential Organ Failure Assessment (SOFA), Acute Physiology and Chronic Health Evaluation (APACHE) II, Simplified Acute Physiology Score (SAPS) II, European System for Cardiac Operative Risk Evaluation (EuroSCORE) II.
in our study, as in 3 of the 4 variables of in-hospital morbidity (CSICU LOS, mechanical ventilation time, and CSICU readmission) SOFA excelled, compared with the other scoring systems except for CASUS, displaying more than adequate results at predicting prognosis. An exception was observed in the case of potential reintubation, where SOFA score was barely significant whereas APACHE II score was significantly associated with the possibility of a reintubation. APACHE II and SAPS II scores were the postoperative scores that were least correlated with the morbidity determinants.

In the past decade, EuroSCORE has been used to predict both in-hospital mortality and morbidity in numerous cardiac surgery centers worldwide. In a large study including 6222 cardiac surgery patients and comparing 19 scoring systems, the discriminatory power for 30-day mortality was highest for EuroSCORE, almost similarly to the Cleveland Clinic score, developed in the United States. All these systems, initially developed to estimate intraoperative and perioperative death, are based mainly on preoperative general risk factors.

As shown elsewhere, EuroSCORE overestimated mortality, having been already characterized as an outdated scoring system. EuroSCORE II, recently created as a necessary feature for preoperative description of the cardiac surgery mortality risk, has shown a remarkable level of discrimination with an AUC of 0.81 in predicting clinical outcome in the development study. Similarly, in the present study, EuroSCORE II exhibited an excellent discrimination concerning 30-day mortality, with an AUC of 0.87. However, contrary to previous findings, it did not appear to be equally reliable for predicting in-hospital morbidity. One possible explanation is that EuroSCORE II exclusively consists of preoperative and intraoperative parameters, whereas postoperative events may have influenced the duration of mechanical ventilation and LOS in the CSICU.

Nonetheless, the performance of the general scoring systems in accordance to discrimination and calibration statistics could not prevail over a specialized cardiac surgery scoring system that took into account the special circumstances encountered in the ICU after cardiac surgery, such as CASUS. Thus the primary research hypothesis for our study seems to be confirmed. CASUS clearly demonstrates superiority over other scoring systems for predicting outcomes, both in previously published studies and in our study.

Our study does have certain limitations. First, the relatively limited size of our sample, due to lack of financial and human resources as well as the single-center character, might limit the generalizability of the findings. Second, scores for the examined systems were calculated only for patients’ first 24 hours in the CSICU. Daily calculation of CASUS and of scores from other systems would allow mortality to be predicted more precisely for every additional day of hospitalization in the CSICU, since logistic versions are enhanced with coefficients weighted for the length of stay in the ICU. The fact that the overall length of stay in the CSICU in our case appeared limited, with a median value of 46 hours, prevented us from continuing to collect clinical data and from calculating scores beyond the first 24 hours.

On the other hand, the prospective design of the present study minimizes potential sources of bias and confounding, as well as incomplete data, which are common problems in retrospective design, thus giving the study remarkable strength. Additionally, selection bias was prevented in other ways; for example, our sample consisted of a rather homogeneous population, such as cardiac surgery patients, and mirrors the daily practice in our CSICU, since all the admissions were consecutive. Finally, although several studies comparing the performance of different severity scores in CSICU patients have been published, the present study is among the few studies that tested the CASUS along with EuroSCORE II and the general prognostic scoring systems.

Conclusions

All the examined scoring systems were highly correlated with the clinical outcome of cardiac surgery patients and feature remarkable statistics concerning the predictive power. CASUS transcends and emerges as the most reliable and beneficial option for benchmarking and risk stratification in cardiac surgery patients. EuroSCORE II and SOFA follow in performance at predicting 30-day mortality and in-hospital morbidity, respectively.

Acknowledgments

We warmly thank the medical and nursing staff of the cardiac surgical intensive care unit at Evangelismos Hospital, Athens, Greece for their generous contributions in clinical data collection for the study.

Financial Disclosures

None reported.

eLetters

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CE Test  Test ID A1524042: Scoring Systems for Outcome Prediction in a Cardiac Surgical Intensive Care Unit: A Comparative Study

Learning objectives: 1. Compare and contrast 5 scoring systems and their ability to predict morbidity and mortality in the cardiac patient population. 2. Identify preoperative, intraoperative, and postoperative variables when using a prospective study. 3. Describe the performance of each scoring system.

1. Which of the following problem statements best describes the context of the study?
   a. Clinical outcome scoring systems provide an accurate predictor for outcomes in the cardiac patient population.
   b. Currently available clinical outcome scoring systems are not designed for application in the cardiac surgery patient population.
   c. Clinical outcome scoring systems focus on preoperative variables thus limiting their use for postoperative morbidity and mortality.
   d. Clinical scoring systems require a redesign to ensure morbidity and mortality for patients in the cardiac surgery population are addressed.

2. Which of the following scoring systems is used to predict operative mortality following open-heart surgery?
   a. Simplified Acute Physiology Score (SAPS) II
   b. Sequential Organ Failure Assessment (SOFA)
   c. Acute Physiology and Chronic Health Evaluation (APACHE) II
   d. European System for Cardiac Operative Risk Evaluation (EuroSCORE)

3. Which of the following describes how mortality was defined for the purpose of this study?
   a. Death within 30 days of surgery
   b. Death within the perioperative period
   c. Death associated with postsurgical complications
   d. Death within 30 days of surgery that occurs during hospitalization

4. Which of the following describes a limitation of the study?
   a. It was only applied to patients who had open-heart surgery.
   b. There was a larger than normal sample size.
   c. It was conducted at a single hospital.
   d. Scores were calculated over a 48-hour unit stay

5. The greatest percentage of deaths occurred during which of the following surgical procedures?
   a. Isolated valve surgeries
   b. Ascending aorta and aortic arch surgery
   c. Postinfarction ventricular septal rupture closure
   d. Coronary artery bypass graft

6. Which indicator shows calibration measures and the discriminative ability of each scoring system?
   a. Brier
   b. Hosmer-Lemeshow
   c. Nagelkerke pseudo-$R^2$
   d. Spearman correlation coefficient

7. Which of the following was the average length of stay for participants in the study?
   a. 24 hours
   b. 32 hours
   c. 46 hours
   d. 72 hours

8. Which of the following had highest correlations to in-hospital mortality?
   a. Reintubation and mechanical ventilation
   b. Length of cardiopulmonary bypass and mechanical ventilation
   c. Length of intubation and need to reintubation
   d. Cross clamp time and length of intubation

9. Which of the following scoring systems proved superior for predicting mortality in patients who had open-heart surgery?
   a. SAPS II
   b. Cardiac Surgery Score (CASUS)
   c. APACHE II
   d. EuroSCORE

10. Which of the following scoring systems proved least satisfactory for predicting mortality in patients who had open-heart surgery?
    a. SAPS II
    b. CASUS
    c. APACHE II
    d. SOFA

11. Scoring systems that were initially developed to estimate intraoperative and perioperative death are based mainly on which factors?
    a. Preoperative general risk factors
    b. Age and sex of the patient
    c. Type of surgery and time on cardiopulmonary bypass
    d. Use of mechanical ventilation

12. What percent of patients in the study required readmission to the cardiac surgical intensive care unit?
    a. 6%
    b. 12%
    c. 18%
    d. 24%

Test ID: A1524042 Contact hours: 1.0; pharma 0.0 Form expires: July 1, 2018. Test Answers: Mark only one box for your answer to each question.

1. a  2. a  3. a  4. a  5. a  6. a  7. a  8. a  9. a  10. a  11. a  12. a
   c  b  c  b  b  b  c  c  c  b  d  d

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Program evaluation

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Atrial Fibrillation and Mortality in Critically Ill Patients: A Retrospective Study

By Sachin Gupta, MBBS, MD, FCIICM, Ravindranath Tiruvoipati, MBBS, MS, FRCSEd, MCh, MSc, EDIC, and Cameron Green, BSc, Pg Dip (Psych), MSc

Background. Although atrial fibrillation is common in critically ill patients, no large studies on its impact on patient mortality in general intensive care units have been done.

Objective. To evaluate the association between atrial fibrillation and hospital mortality in critically ill patients.

Methods. In a retrospective cohort study, critically ill patients who had atrial fibrillation during a 2-year period were compared with patients who did not. The primary outcome was death during the hospital stay. Secondary outcomes were duration of mechanical ventilation and lengths of stay in the intensive care unit and hospital.

Results. Among a total of 2018 first-time admissions to the intensive care unit during the study period, 421 patients (20.9%) had atrial fibrillation. Patients with atrial fibrillation had higher mortality, significantly longer duration of mechanical ventilation, and longer stays in the intensive care unit and in the hospital than did patients without this cardiac arrhythmia. However, multiple logistic regression analysis indicated that atrial fibrillation was not independently associated with a higher risk for death.

Conclusion. Atrial fibrillation may not be independently associated with hospital mortality. (American Journal of Critical Care. 2015;24:336-341)
Atrial fibrillation is a supraventricular tachyarrhythmia characterized by uncoordinated atrial activation with consequent deterioration of atrial mechanical function. Atrial fibrillation is classified clinically as paroxysmal (episodes lasting ≤ 7 days), persistent (continuous episodes for > 7 days), longstanding persistent (continuous episodes for > 12 months), and permanent (no further attempts to restore or maintain sinus rhythm).

Atrial fibrillation is a common arrhythmia in intensive care unit (ICU) patients and may be associated with an increase in mortality. Several factors predispose ICU patients to this arrhythmia. Estimates of the incidence of atrial fibrillation in critically ill patients range from 47.4% to 61% of all arrhythmias and 52% of atrial arrhythmias. In a study of surgical ICU patients, the incidence was 5.3%.

Atrial fibrillation is a supraventricular tachyarrhythmia characterized by uncoordinated atrial activation with consequent deterioration of atrial mechanical function. Atrial fibrillation is classified clinically as paroxysmal (episodes lasting ≤ 7 days), persistent (continuous episodes for > 7 days), longstanding persistent (continuous episodes for > 12 months), and permanent (no further attempts to restore or maintain sinus rhythm). Even though atrial fibrillation occurred in a large proportion of patients, it was not analyzed separately in the multivariable logistic regression analyses. Although various organizations have issued guidelines for the management of atrial fibrillation, little high-level evidence is available to guide the choice of therapy for atrial fibrillation in ICU patients. In a recent systematic review, Kanji et al concluded that well-designed randomized controlled trials to evaluate rhythm conversion in critically ill adult patients outside cardiac surgery care are lacking.

The primary aim of our study was to evaluate the association between atrial fibrillation in the ICU and hospital mortality. Secondary outcomes were duration of mechanical ventilation and lengths of stay in the ICU and hospital. We hypothesized that atrial fibrillation in critically ill patients is associated with increased hospital mortality.
Patients and Data Sources
Clinical data for all of the patients were recorded in CareVue (a clinical information system supported by Philips Healthcare), including observations, clinical notes, and laboratory parameters. Electronically recorded data were searched for the phrase “atrial fibrillation” in the observation chart of all the patients admitted to the ICU. Atrial fibrillation was recorded in the charts on the basis of electrocardiographic interpretation by the bedside nurses. Only initial ICU admissions of patients who had atrial fibrillation within the same hospital stay were included in the analysis. All patients who had at least 1 recorded episode of atrial fibrillation were included in the study. Patients who were given palliative care at the time of onset of atrial fibrillation were excluded from the subgroup analysis but not from analysis of the group with atrial fibrillation as a whole. Atrial fibrillation in the patients given palliative care could have contributed to the patients’ severity of illness, but the palliative intent would have confounded the choice of therapy. Data on patients with other atrial arrhythmias (atrial flutter, multifocal atrial tachycardia, and other supraventricular arrhythmias) were excluded from analysis.

Variables
Atrial fibrillation was defined as preexisting (history of persistent or paroxysmal atrial fibrillation) or new onset (atrial fibrillation first observed in the ICU in patients with no history of the arrhythmia). The number of times the phrase atrial fibrillation appeared in a patient’s observation chart during the ICU stay was recorded as instances (episodes).

Data on age, sex, scores on the Acute Physiology and Chronic Health Evaluation II (APACHE II), duration of ventilation, and ICU and hospital lengths of stay were retrieved from the hospital dataset. Patients who had cardiopulmonary bypass for their surgeries (eg, coronary artery bypass grafting, aortic root repair, valve replacement) were classified as postcardiopulmonary bypass. The primary outcome was death during the hospital stay. Secondary outcomes were duration of mechanical ventilation, ICU length of stay, and hospital length of stay.

Hemodynamic data such as heart rate at the onset of atrial fibrillation, maximum heart rate while in atrial fibrillation, corresponding mean arterial pressures, use of inotropes, and treatments (eg, amiodarone, direct-current cardioversion) used for cardioversion of atrial fibrillation and to control the ventricular rate were noted. Use of therapeutic anticoagulation (oral and intravenous anticoagulants) was recorded.

Complications of atrial fibrillation, including thromboembolic phenomena (eg, stroke, mesenteric infarction) and hemodynamic compromise were noted. Stroke was defined as a focal neurological deficit evident on clinical examination associated with occurrence of atrial fibrillation, either at the time of ICU admission or during the ICU stay, as determined by the ICU physician. Unstable hemodynamic status was defined as an increase in the rate of infusion of noradrenaline or adrenaline by more than 2 μg/min at the time of onset of atrial fibrillation.

Comorbid conditions in patients who experienced atrial fibrillation were recorded from the notes on admission, along with the patients’ baseline medications.

Statistical Methods
Continuous variables with skewed distribution were described as median and interquartile ranges. The Wilcoxon rank sum test was used to calculate the significance of differences between 2 groups. Categorical variables were compared and tested for significance of difference between outcomes by using a χ² test. P values less than .05 were considered significant. A secondary analysis based on multiple logistic regression was conducted with atrial fibrillation, age, and APACHE II scores as covariates to test independent association of atrial fibrillation with mortality.

Results
Among the 2018 first ICU admissions during the study period, data on 421 patients (20.9%) were analyzed in a comparison of patients with atrial fibrillation with patients without the arrhythmia (see Figure). Demographics and characteristics of patients included in the study are presented in Table 1. Most of the patients received magnesium or amiodarone for management of atrial fibrillation.
Among 399 patients, 22 had a stroke in association with atrial fibrillation (5.5%). Among these 22 patients, 1 had a stroke at the time of ICU admission, 8 had a stroke after being on cardiopulmonary bypass, and 1 had a stroke during atrial fibrillation in the ICU. Only a minority of patients with stroke and atrial fibrillation could be given anticoagulants because of the higher risk for bleeding in these patients. Compared with patients without atrial fibrillation, patients with atrial fibrillation were older, had higher APACHE II scores, stayed longer in the ICU and in the hospital, and required mechanical ventilation for a longer duration (Table 2). Atrial fibrillation had a significant association with higher mortality (odds ratio, 2.0; 95% CI, 1.5-2.6). However, in a multivariable logistic regression model consisting of atrial fibrillation, APACHE II scores, and age, atrial fibrillation was not independently associated with higher mortality (odds ratio, 1.3; 95% CI, 0.94-1.89). APACHE II scores were independently associated with increased hospital mortality (odds ratio, 1.27; 95% CI, 1.23-1.30).

Patients with new-onset atrial fibrillation had demographic profiles and severity of illness scores similar to those of patients with preexisting atrial fibrillation (Table 3). These 2 groups also had similar outcomes, including duration of mechanical ventilation, ICU and hospital lengths of stay, and incidence of stroke. However, a significantly higher number of patients with new-onset atrial fibrillation needed inotropes and amiodarone. Patients who had preexisting atrial fibrillation had a higher number of instances of atrial fibrillation (Table 3).

**Discussion**

The incidence of atrial fibrillation in our study was similar to the incidence in studies of medical ICU patients but higher than the incidence in surgical ICU patients. Outcomes were significantly worse in the critically ill patients who had atrial fibrillation than in those without atrial fibrillation. However, as suggested by multiple logistic regression analysis, atrial fibrillation was not independently associated with mortality; most likely the arrhythmia is a marker of critical illness. Outcomes for patients with new-onset atrial fibrillation did not differ significantly from the outcomes for patients with preexisting atrial fibrillation, suggesting that on its own, preexisting atrial fibrillation may not be associated with worse outcomes. The finding that more patients in the new-onset group needed amiodarone and inotropes may be attributable to the higher ventricular rate in the new-onset group (new-onset group, 115.5/min; preexisting group, 97/min; \( P < .001 \)) along with a slightly lower median mean arterial pressure (new-onset group, 78 mm Hg; preexisting group, 80.5 mm Hg; \( P = .02 \)).

Our study is the first of its kind in general ICU patients with a focus on atrial fibrillation alone. In a recently published retrospective cohort study based on inpatient administrative claims data for patients admitted with severe sepsis, new-onset atrial fibrillation was independently associated with mortality; most likely the arrhythmia is a marker of critical illness. Outcomes for patients with new-onset atrial fibrillation did not differ significantly from the outcomes for patients with preexisting atrial fibrillation, suggesting that on its own, preexisting atrial fibrillation may not be associated with worse outcomes. The finding that more patients in the new-onset group needed amiodarone and inotropes may be attributable to the higher ventricular rate in the new-onset group (new-onset group, 115.5/min; preexisting group, 97/min; \( P < .001 \)) along with a slightly lower median mean arterial pressure (new-onset group, 78 mm Hg; preexisting group, 80.5 mm Hg; \( P = .02 \)).

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**Table 1**

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<td>After cardiopulmonary bypass</td>
<td>156 (39.1)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>58 (14.5)</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>22 (5.5)</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>20 (5)</td>
</tr>
<tr>
<td>Other</td>
<td>143 (35.8)</td>
</tr>
<tr>
<td><strong>Patients requiring mechanical ventilation</strong></td>
<td>335 (84.0)</td>
</tr>
<tr>
<td><strong>Duration of mechanical ventilation, median (interquartile range), h</strong></td>
<td>42 (13-161)</td>
</tr>
<tr>
<td><strong>Days in intensive care unit, median (interquartile range)</strong></td>
<td>4 (1.9-8.9)</td>
</tr>
<tr>
<td><strong>Days in hospital, median (interquartile range)</strong></td>
<td>17.7 (10.2-33)</td>
</tr>
<tr>
<td><strong>Hospital mortality</strong></td>
<td>89 (22.3)</td>
</tr>
<tr>
<td><strong>Discharge to rehabilitation</strong></td>
<td>180 (45.1)</td>
</tr>
<tr>
<td><strong>Discharge to home</strong></td>
<td>128 (32.1)</td>
</tr>
<tr>
<td><strong>Complications</strong></td>
<td></td>
</tr>
<tr>
<td>Unstable hemodynamic status</td>
<td>62 (15.5)</td>
</tr>
<tr>
<td>Thromboembolism</td>
<td>23 (5.8)</td>
</tr>
<tr>
<td>Stroke</td>
<td>22 (5.5)</td>
</tr>
<tr>
<td>Mesenteric ischemia</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td><strong>Comorbid conditions</strong></td>
<td></td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>126 (31.6)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>213 (53.4)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>97 (24.3)</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>29 (7.3)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>99 (24.8)</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>10 (2.5)</td>
</tr>
<tr>
<td>Hyperthyroidism</td>
<td>5 (1.2)</td>
</tr>
<tr>
<td>Hypothyroidism</td>
<td>17 (4.3)</td>
</tr>
<tr>
<td><strong>Therapy</strong></td>
<td></td>
</tr>
<tr>
<td>Amiodarone</td>
<td>218 (54.6)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>282 (70.7)</td>
</tr>
<tr>
<td>Digoxin</td>
<td>118 (29.6)</td>
</tr>
<tr>
<td>( \beta )-Blockers</td>
<td>138 (34.6)</td>
</tr>
<tr>
<td>Electrical cardioversion</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Anticoagulation</td>
<td>118 (29.6)</td>
</tr>
</tbody>
</table>

\(^{a}\) Data are for 399 patients analyzed for subgroup analysis of atrial fibrillation group.

\(^{b}\) Numbers in second column are number (percentage) of patients unless otherwise specified in this column.

\(^{c}\) Other included drug overdose, pancreatitis, and postoperative care after neurosurgery, orthopedic surgery, and thoracic surgery.
fibrillation was associated with increased risk for hospital mortality. However, the investigation did not include APACHE II scores in its regression model.

Our study has several limitations. First it was a retrospective study. In addition, we did not do sample-size calculations before the study began, and type II error might account for our results. The study was further characterized by immortal time bias. Compared with patients in the atrial fibrillation group, patients in the group without atrial fibrillation may have died earlier, before any atrial fibrillation developed. However, the number of patients without atrial fibrillation was small and may not have affected our results. Patients were not treated according to a set protocol, introducing several confounding factors in the analysis. For this reason, no conclusions about the efficacy of pharmacological treatment can be drawn on the basis of our data. We could not ascertain how many patients with new-onset atrial fibrillation had the arrhythmia when they were discharged from the hospital. Only some of the patients with atrial fibrillation had transthoracic echocardiograms; hence, findings from such studies could not be included in our analyses. Definition of atrial fibrillation and its differentiation from other atrial and supraventricular arrhythmias depended on the judgment of the bedside nurse, a situation that can introduce inherent bias and variability.

ACKNOWLEDGMENTS
This study was performed in the Department of Intensive Care at St Vincent’s Hospital. We thank Mr David Reid, Mr Roger Smith, and Dr Bernadette Hickey, intensive care unit, St Vincent’s Hospital, for their assistance in data analysis and manuscript preparation.

FINANCIAL DISCLOSURES
None reported.

Table 2
Comparison of patients with and without atrial fibrillation in the intensive care unit

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>With (n = 421)</th>
<th>Without (n = 1597)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (interquartile range), y</td>
<td>71 (64-77)</td>
<td>63 (50-72)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Score on Acute Physiology and Chronic Health Evaluation II, median (interquartile range)</td>
<td>19 (15-23)</td>
<td>16 (11-19)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Mechanical ventilation, median (interquartile range), h</td>
<td>42 (13-151)</td>
<td>15 (6-32)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Days in intensive care unit, median (interquartile range)</td>
<td>4 (1.85-8.89)</td>
<td>1.23 (0.85-2.8)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Days in hospital, median (interquartile range)</td>
<td>17.7 (10.77-34.04)</td>
<td>10.67 (6.36-20.96)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Death (mortality)</td>
<td>89 (21.1)</td>
<td>185 (11.6)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Hospital discharge destination
- Rehabilitation: 38 (9.0) vs 104 (6.5), P = .03
- Nursing home: 3 (0.7) vs 7 (0.4), P = .37
- Home: 129 (30.6) vs 927 (58.0), P = .29
- Other hospital: 160 (38.0) vs 396 (24.8), P = .05

* Numbers in second and third columns are number (percentage) of patients unless otherwise specified in this column.

Table 3
Comparison of patients with preexisting vs new-onset atrial fibrillation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Preexisting (n = 145)</th>
<th>New onset (n = 254)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>71 (64-77)</td>
<td>72 (64-77)</td>
<td>.75</td>
</tr>
<tr>
<td>Score on Acute Physiology and Chronic Health Evaluation II</td>
<td>19 (15-24)</td>
<td>19 (15-23)</td>
<td>.38</td>
</tr>
<tr>
<td>Days in intensive care unit</td>
<td>3.8 (1.8-9.5)</td>
<td>4.1 (1.9-8.1)</td>
<td>.99</td>
</tr>
<tr>
<td>Days in hospital</td>
<td>18.1 (9.2-31.9)</td>
<td>17.5 (10.8-33)</td>
<td>.55</td>
</tr>
<tr>
<td>Hospital mortality, No. (%) of patients</td>
<td>54 (37.2)</td>
<td>35 (13.8)</td>
<td>.64</td>
</tr>
<tr>
<td>Hours of mechanical ventilation</td>
<td>44 (15-177)</td>
<td>41 (12-135)</td>
<td>.31</td>
</tr>
<tr>
<td>Cardiopulmonary bypass, No. (%) of patients</td>
<td>49 (33.8)</td>
<td>105 (41.3)</td>
<td>.08</td>
</tr>
<tr>
<td>Yes</td>
<td>49 (33.8)</td>
<td>105 (41.3)</td>
<td>.08</td>
</tr>
<tr>
<td>No</td>
<td>96 (66.2)</td>
<td>149 (58.7)</td>
<td></td>
</tr>
<tr>
<td>Heart rate, beats per minute</td>
<td>97 (81.5-116)</td>
<td>115.5 (96-140)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Highest heart rate, beats per minute</td>
<td>124 (105-140)</td>
<td>134 (110-154)</td>
<td>.002</td>
</tr>
<tr>
<td>Mean arterial pressure, mm Hg</td>
<td>80.5 (71-94.5)</td>
<td>78 (69-90)</td>
<td>.02</td>
</tr>
<tr>
<td>Treatment, No. (%) of patients</td>
<td>101 (69.7)</td>
<td>202 (79.5)</td>
<td>.03</td>
</tr>
<tr>
<td>Inotropes</td>
<td>42 (28.3)</td>
<td>77 (30.3)</td>
<td>.72</td>
</tr>
<tr>
<td>Anticoagulation</td>
<td>6 (4.1)</td>
<td>16 (6.3)</td>
<td>.32</td>
</tr>
<tr>
<td>Stroke, No. (%) of patients</td>
<td>27 (4-11)</td>
<td>11 (4-30)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Instances of atrial fibrillation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Numbers in second and third columns are median (interquartile range) unless otherwise specified in this column.
REFERENCES


10. Tselentakis EV, Woodford E, Chandy J, Gaudette GR, Saltview of the article.


To purchase electronic or print reprints, contact American Association of Critical-Care Nurses, 101 Columbia, Aliso Viejo, CA 92656. Phone, (800) 899-1712 or (949) 362-2050 (ext 532); fax, (949) 362-2049; e-mail, reprints@aacn.org.
FACTORS ASSOCIATED WITH OCCIPITAL PRESSURE ULCERS IN HOSPITALIZED INFANTS AND CHILDREN

By Mary-Jeanne Manning, MSN, APRN, PNP-BC, CCRN, Kimberlee Gauvreau, ScD, and Martha A.Q. Curley, RN, PhD

Background The occiput is a common location for development of pressure ulcers in hospitalized infants and young children. However, risk factors associated with occurrence of the ulcers have not been fully described.

Objective To identify factors associated with development of occipital pressure ulcers in acutely ill infants and children.

Methods Charts of all patients with occipital pressure ulcers reported in a computerized safety event reporting system since its implementation in 2005 and of any patients with such ulcers recalled by members of the skin care special interest group were reviewed retrospectively.

Results During a 4-year period, 60 cases of occipital pressure ulcers were identified: 40% stage I, 12% stage II, 30% unstageable, and 18% deep tissue injury. The median age of the sample was 12 months. Among the patients, 86% were in the intensive care unit with cardiovascular or pulmonary problems. A total of 68% had comorbid conditions. Most of the patients were less than 1 year old; were critically ill, requiring high-risk therapies; and had multiple medical devices in place. Patients with the ulcers were commonly treated with mechanical ventilation (83%) and sedation (74%) and were described as agitated (42%). Many of these patients were receiving vasoactive medications (50%) and had vascular access devices in the neck that restricted head movement (45%). When documented, the median Braden Q score was 16.

Conclusions Infants and children at risk for occipital pressure ulcers can be prospectively identified, allowing implementation of nursing interventions to prevent these ulcers. (American Journal of Critical Care. 2015;24:342-348)
Maintenance of skin integrity in hospitalized patients is a critical component of nursing care. Immobility-related pressure ulcers are defined as localized areas of tissue destruction that develop when soft tissue is compressed between a bony prominence and an external surface for a prolonged time. As indicators of the quality or outcomes of care most affected by the assessment and interventions provided by nurses, the occurrence of pressure ulcers is being monitored more closely now than ever before. The Centers for Medicare and Medicaid Services in 2006 declared that hospital-acquired stage III or stage IV pressure ulcers are adverse, preventable patient safety events. In addition, pressure ulcers increase the financial and personal cost of health care. Nurses are in a pivotal position to improve care and prevent immobility-related pressure ulcers.

Until recently, pressure ulcers in infants and children were not considered a research priority. We now know that pressure ulcers do occur in these patients; the reported incidence is 4% to 27%. Despite the growing awareness of pressure ulcers in infants and children, little is known about the nuances of risk in this age group. Data specific for infants and children are needed to help bedside nurses prevent and manage pressure ulcers in at-risk young patients.

Most of the research to date has centered on tools to assess a patient’s risk. Few specific data are available on factors associated with the development of occipital pressure ulcers (OPUs), the type most common in infants and children. These unique pressure ulcers are particularly important because of their high potential for more severe injury, such as osteomyelitis, and life-long scarring alopecia. The purpose of this study was to identify factors commonly associated with the development of OPUs in hospitalized infants and children.

**Methods**

A retrospective chart audit was performed at Boston Children’s Hospital (BCH), Boston, Massachusetts. This acute care facility is a 395-bed university-affiliated children’s hospital that admits approximately 17,000 young patients per year. The study population consisted of infants and children known to have had an OPU while hospitalized between January 2006 and April 2010. Data were collected on patients with hospital-acquired OPUs. Data on patients who had pressure ulcers at the time of admission to the hospital or had no documented skin assessments before the discovery of the OPU were excluded from the study. Occurrences of OPU were detected through purposeful sampling of cases reported in the hospital's electronic safety event reporting system (SERS) after implementation of the system in 2005. In addition, the study included data on cases of OPU recalled by members of the BCH skin care special interest group, which included staff nurses throughout the institution and nurse practitioners in plastic surgery and wound and ostomy care. The purpose of the second step was to ensure inclusion of data on cases that might not have been reported in the SERS.

Expert members of the skin care special interest group and clinical nurse specialists from the cardiovascular and critical care program at BCH collected data by using the case report forms of the Braden Q validation study. Data included demographic variables, Braden Q scores, use of medical devices, and interventions to prevent skin injury. All data were deidentified to maintain patients’ anonymity. The study was approved by the appropriate institutional review board. Informed consent was waived.

Data were extracted from either a paper medical record (through April 2007) or an electronic medical record (after April 2007). Demographic variables included age, race, sex, weight, and primary diagnosis. Study variables included Braden Q scores; length of stay in the intensive care unit (ICU); hospital
length of stay; presence of comorbid conditions; the number of days from hospital admission to discovery of the pressure ulcer; severity of illness scores determined by using the Pediatric Risk of Mortality III15 and the Risk Adjusted in Congenital Heart Surgery16 scoring tools; use of medical devices; ventilation modes; administration of vasoactive agents; presence of support surfaces; and presence of other pressure ulcers. Nutritional status was assessed by reviewing nutrition notes and documented caloric intake. Sedation scores were extracted for intubated ICU patients. The sedation scale used at BCH is the State Behavioral Scale.17 This instrument is a 5-point scale ranging from -3 (unresponsive state) to +2 (agitated state). Data on devices included presence of the following: endotracheal tubes (nasal, oral), nasogastric tubes, vascular access devices that limit head movement (central venous catheters, extracorporeal membrane oxygenation catheters), electroencephalographic leads, helmets, cervical collars, goggles for bilirubin lights, bispectral index leads, near-infrared spectrometry leads, noninvasive ventilation masks, and oxygen saturation probes.

The Braden Q Risk Assessment tool is a valid and reliable instrument for predicting the risk for immobility-related pressure ulcers in infants and children.14 At BCH, routine Braden Q scoring was not formally introduced until April 2008. When available, Braden Q subscale and total scores were collected for the date a pressure ulcer was discovered and for 24, 48, and 72 hours before the discovery. Staging was performed according to the National Pressure Ulcer Advisory Panel definitions.18 Staging of wounds was extracted from patients’ medical records. If the stage of the pressure ulcer was not documented, a stage based on the existing descriptions found within the SERS report or medical record was assigned.

Results

A total of 60 patients met the study criteria. Demographic data are noted in Table 1. Median age at the time the ulcer was discovered was 12 months (interquartile range, 3-28 months). A total of 57% of the patients were male, 55% were white, and 53% were critically ill with a primary cardiovascular diagnosis. Most of the cardiac surgical patients had scores of 3 or greater on the Risk Adjustment in Congenital Heart Surgery tool, indicating a moderate to high risk for death. Among the patients, 68% had a comorbid condition such as heart disease, traumatic injury, or pulmonary hypertension. Of note, 28% were less than the fifth percentile for weight.

Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (interquartile range), months</td>
<td>12 (3-28)</td>
</tr>
<tr>
<td>Male sex</td>
<td>34 (57)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>33 (55)</td>
</tr>
<tr>
<td>Not documented</td>
<td>14 (23)</td>
</tr>
<tr>
<td>Black</td>
<td>6 (10)</td>
</tr>
<tr>
<td>&gt; 1 Race</td>
<td>3 (5)</td>
</tr>
<tr>
<td>Asian, Native American, Middle Eastern</td>
<td>4 (7)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>9 (15)</td>
</tr>
<tr>
<td>Not Hispanic/Latino</td>
<td>9 (15)</td>
</tr>
<tr>
<td>Not documented</td>
<td>20 (33)</td>
</tr>
<tr>
<td>Unknown</td>
<td>22 (37)</td>
</tr>
<tr>
<td>Primary diagnosis</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>32 (53)</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>20 (33)</td>
</tr>
<tr>
<td>Other</td>
<td>8 (13)</td>
</tr>
<tr>
<td>Comorbid conditions</td>
<td></td>
</tr>
<tr>
<td>Intensive care</td>
<td>56 (93)</td>
</tr>
<tr>
<td>Medical-surgical intensive care unit (n = 26) PRISM score, median (interquartile range); range</td>
<td>4 (1-12); 0-91</td>
</tr>
<tr>
<td>Cardiac intensive care unit (n = 30) RACHS score ≥ 3</td>
<td>19 (63)</td>
</tr>
<tr>
<td>Weight, median (interquartile range); range</td>
<td>8.2 (4.3-13); 1.6-83.6</td>
</tr>
<tr>
<td>Weight &lt; 5th percentile</td>
<td>17 (28)</td>
</tr>
</tbody>
</table>

Abbreviations: PRISM, Pediatric Risk of Mortality III; RACHS, Risk Adjusted in Congenital Heart Surgery.

Values are number (percentage) of patients unless indicated otherwise. Percentages may not total 100 because of rounding.

Table 2

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital length of stay before occipital pressure ulcer discovered, median (interquartile range), days</td>
<td>17 (9-34)</td>
</tr>
<tr>
<td>Length of stay in intensive care unit (n = 59), median (interquartile range), days</td>
<td>24 (10-45)</td>
</tr>
<tr>
<td>Stage of pressure ulcer, No. (%) of patients</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>24 (40)</td>
</tr>
<tr>
<td>II</td>
<td>7 (12)</td>
</tr>
<tr>
<td>Unstageable</td>
<td>18 (30)</td>
</tr>
<tr>
<td>Suspected deep tissue injury</td>
<td>11 (18)</td>
</tr>
<tr>
<td>Multiple pressure ulcers</td>
<td>25 (42)</td>
</tr>
</tbody>
</table>

Results
Many of the patients required life-sustaining therapies (Table 3). At the time of discovery, 83% of the patients were being treated with mechanical ventilation; among these, 40% had neuromuscular blockade, 14% received high-frequency oscillatory ventilation, and 8% had extracorporeal membrane oxygenation. Although 74% of the patients were receiving sedatives, scores on the State Behavioral Scale indicative of agitation were recorded in 42% of these patients. Among the sample population, 50% were receiving vasoactive medications, and 45% had a central venous catheter or extracorporeal membrane oxygenation cannulas that restricted head movement.

Braden Q subscores were determined at several times. When documented, the median Braden Q score on the day closest to discovery of the OPU was 16 (interquartile range, 15-18). Table 4 presents the data collected on the day of discovery of the OPU and within 72 hours before discovery of the ulcer. These data indicate that the patients in the sample were often not ambulatory, taken out of the bed, or held on the days before discovery of the ulcers.

Repositioning of patients was difficult to determine because of inconsistencies in documentation. Most patients were receiving neuromuscular blockers and sedatives or analgesics. The head of the bed was elevated 30° or less in most instances. Nutrition was not optimal in these patients as indicated by lack of full caloric intake for age and low serum levels of albumin. When documented, 27% (16 patients) had a specialty mattress (Z-Flow, Sundance Enterprises Inc; KCI First Step overlay, Motion Specialties; gel mattress), and 22% (13) had a device documented as being placed under the head (gel pillow, Z-Flow mattress).

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Therapies for occipital pressure ulcers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Therapy</td>
<td>No. (%) of patients</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Endotracheal tube</td>
<td>53 (88)</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>7 (12)</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>50 (83)</td>
</tr>
<tr>
<td>High-frequency oscillatory</td>
<td>7 (12)</td>
</tr>
<tr>
<td>Noninvasive</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Extracorporeal membrane oxygenation</td>
<td>5 (8)</td>
</tr>
<tr>
<td>Central venous catheter</td>
<td>27 (45)</td>
</tr>
<tr>
<td>Vasoactive medications</td>
<td>30 (50)</td>
</tr>
<tr>
<td>Nasogastric tube</td>
<td>36 (60)</td>
</tr>
<tr>
<td>Saturation probe</td>
<td>55 (92)</td>
</tr>
<tr>
<td>Electroencephalography leads</td>
<td>3 (5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Documented assessment points per Braden Q subscale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment</td>
<td>Day of discovery</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
</tr>
<tr>
<td>Mobility</td>
<td></td>
</tr>
<tr>
<td>Repositioning</td>
<td>38 (63)</td>
</tr>
<tr>
<td>Activity</td>
<td></td>
</tr>
<tr>
<td>Out of bed/held</td>
<td>15 (25)</td>
</tr>
<tr>
<td>Sensory perception</td>
<td></td>
</tr>
<tr>
<td>Neuromuscular blockade</td>
<td>24 (40)</td>
</tr>
<tr>
<td>Sedatedb</td>
<td>12 (20)</td>
</tr>
<tr>
<td>Agitatedc</td>
<td>19 (32)</td>
</tr>
<tr>
<td>Receiving opioids</td>
<td>43 (72)</td>
</tr>
<tr>
<td>Receiving benzodiazepines</td>
<td>39 (65)</td>
</tr>
<tr>
<td>Moisture</td>
<td></td>
</tr>
<tr>
<td>Fever &gt; 38°C</td>
<td>11 (18)</td>
</tr>
<tr>
<td>Friction shear</td>
<td></td>
</tr>
<tr>
<td>Head-of-bed elevation ≥ 30°</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Nutrition</td>
<td></td>
</tr>
<tr>
<td>Albumin, median (interquartile range), g/dL</td>
<td>2.9 (1.8-4.2)</td>
</tr>
<tr>
<td>Receiving sufficient calories for age</td>
<td>19 (32)</td>
</tr>
<tr>
<td>Tissue perfusion and oxygenation</td>
<td></td>
</tr>
<tr>
<td>Oxygen saturation, median (interquartile range), %</td>
<td>88 (52-100)</td>
</tr>
<tr>
<td>Capillary refill time, median (interquartile range), seconds</td>
<td>2.5 (1-5)</td>
</tr>
<tr>
<td>Hemoglobin, median (interquartile range), g/dL</td>
<td>11.2 (6.8-18)</td>
</tr>
</tbody>
</table>

a Numbers in second and third columns are number (percentage) of patients unless otherwise specified in this column.
b Score on State Behavioral Scale: -1 or -2.
c Score on State Behavioral Scale: +1 or +2.
**Discussion**

Pressure ulcers are a serious yet preventable complication of care for hospitalized infants and children. Our results provide new information on the factors associated with development of OPUs in this age group. Our study is the first one with a focus on OPUs in infants and children. We found that OPUs most often occurred in young patients with complex medical problems who were experiencing a critical illness. In many instances, OPUs were first identified several weeks into the patient’s hospitalization.

The reported incidence of pressure ulcers in acutely ill infants and children is 4% to 27%. In young children, the occiput is the most frequently reported location for pressure ulcers. Development of a pressure ulcer on the occiput makes sense: a young child’s head is proportionately larger and heavier than the head of an older child. In addition, the occipital area has no adipose tissue to protect it. Friction, shear, and the weight of the head place immobile young children at risk for OPUs.

Recent data suggest that children with medically complex conditions are being readmitted to hospitals in increasing frequency. These patients often become critically ill and require long stays in the ICU. Patients with complex conditions often undergo high-risk treatments. In a retrospective study by Samaniego, 15% of children with myelodysplasia had pressure ulcers. Factors associated with the development of pressure ulcers in our sample included friction, impaired sensation, use of medical devices, and the inability to communicate pain. In a secondary analysis of existing data, Kottner et al found that 75% of infants and children in whom a pressure ulcer developed were chronically or terminally ill.

Our results indicated the use of multiple therapies before a pressure ulcer was discovered. Most patients with an OPU were intubated and receiving mechanical ventilation. The presence of an endotracheal tube, especially in young children, often requires limiting head movement to prevent dislodgement of the tube. Limited head movement may increase the duration of pressure over an area of the occiput. The use of high-frequency oscillatory ventilation will increase friction and shear in the occipital region. In addition, extracorporeal membrane oxygenation is often accomplished via cannulation of vessels in the right side of the neck. The relatively large catheters required and the need for adequate blood flow though those catheters often limit the ability to move a patient’s head. Similarly, patients with a central venous catheter in the neck may have limited movement of their head.

Comfort and safety are important factors in caring for young patients who are receiving mechanical ventilation. Patients who are deeply sedated and those given neuromuscular blockers depend on caregivers for repositioning and use of support surfaces to help relieve pressure. Most of the patients in our study were sedated in the days immediately before discovery of the pressure ulcer. Almost half of the patients were receiving neuromuscular blockers on the days leading up to discovery of the pressure ulcer. Patients who require opioids and benzodiazepines for extended periods are also at risk for iatrogenic withdrawal syndrome when these medications are stopped. The agitation associated with the syndrome leads to increased friction and shear on the occipital area. We found that many patients in our study were described as agitated, as evidenced by their scores on the State Behavioral Scale before the development of an OPU. Longer ICU stays, longer duration of mechanical ventilation, use of sedation and neuromuscular blockade, and agitation all increase the risk for an OPU.

The use of vasoactive medications in many of our patients before the development of an OPU also suggests periods of altered skin perfusion. The combination of immobility and suboptimal perfusion may increase a patient’s risk for an OPU.

The median ICU length of stay in our study was 24 days. Extended lengths of ICU stay have been associated with an increased risk for pressure ulcers.

Consistent with the results of previous investigations in infants and children, stage I and unstageable were the most common stages of pressure ulcer in our patients. The National Pressure Ulcer Advisory Panel revised the staging definitions for pressure ulcers in 2007. This revision included 2 new categories: unstageable and suspected deep tissue injury. These new categories would not have been included in earlier studies of pressure ulcers.

The median Braden Q scores of 16 at the time of admission and on the day closest to the day of discovery of an OPU indicated that these patients were at risk for pressure ulcers. Early identification of risk coupled with interventions to limit skin breakdown may have led to early detection and thus limited progression to a more severe pressure injury.

Adequate nutrition is known to be critically important in wound healing and maintenance of skin integrity. Few of the patients with an OPU in our study were receiving full nutritional feedings around the time the pressure ulcer was discovered. Approximately one-third of our patients were less than the fifth percentile for weight, and many had...
low serum levels of albumin. Lean patients may have limited subcutaneous tissue to cushion boney prominences. McCord et al identified absence of proper nutrition as a risk factor for pressure ulcers in critically ill infants and children. These authors specifically noted that malnutrition may predispose patients to loss of subcutaneous tissue, which may further decrease cushioning of boney prominences.

Our data may be an underestimation of the incidence of OPU's in infants and children. Patients in particularly unstable condition are difficult to turn and reposition to allow full assessment of the occiput. Although only 22% of our patients were children of color, the combination of dark hair and dark skin may also inhibit visualization of pressure wounds. Dixon and Ratliff presented a case study of a 7-year-old boy who experienced the development of several pressure ulcers under track braids during a prolonged ICU stay. Wounds related to such hairstyles may not be detected until the braids or embellishments have been removed.

Limitations

The major limitations of our study include its retrospective design, reliance on existing documentation, changes in the guidelines for staging pressure ulcers, and patterns of prevention over time. We included cases that occurred in a 4-year period from an entire children’s hospital and have precise data on the total number of patients admitted during the data collection period that prevent us from calculating a true OPU rate. In addition, although we relied on our best available methods (existing SERS and the recall of our skin care specialists), we may not have collected data on all patients who had an OPU. Our skin care specialists may have only recalled the most memorable wounds, biasing our data to only the most severe OPU's.

Our documentation system changed several times during the data collection period (January 2006 and April 2010). Before 2007, no Braden Q scores were documented. This situation made it difficult to locate some of our data elements. Not all the OPU's in the study were staged, and some were staged according to previous guidelines of the National Pressure Ulcer Advisory Panel. Retrospective staging is less than optimal and limits the strength of our conclusions. If the new definitions had been used, some of the suspected deep tissue injuries might have been staged differently. Future audits, with computerized documentation systems, will eliminate recall bias and enhance the quality of data extraction.

We did attempt to identify the number of patients supported on a specialized surface and/or which patients had a supportive device placed under the head. Many patients did not have adequate documentation on use of a support surface, and when the information was documented, the timing of use of the support surface was unclear. Solis et al examined interface pressure in healthy children and found that the highest interface pressures occurred on the occiput. They reported a significant decrease in the pressure on the occiput with the use of a foam mattress overlay. Results of their study suggest that using a specialty surface might decrease the incidence of OPU's.

Conclusion

Our study is the first one on factors specifically related to the development of OPU's in infants and children. We found that OPU's occurred in young patients with complex medical problems who were experiencing a critical illness. Most often, the OPU was first identified several weeks into the patient’s hospitalization. Our data help identify factors associated with development of OPU's in acutely ill infants and children. We think that infants and children at risk for OPU's can be identified and that preventative strategies can be implemented to avoid this hospital-acquired complication. Our next step is to systematically design and test nursing interventions to decrease the occurrence and limit the severity of OPU's in infants and children.

Acknowledgment

We thank Elizabeth Tong, RN, MS, PNP, FAAN, for her assistance with data collection. Her expertise and dedication were instrumental to the success of this study.

Financial Disclosures

None reported.

See Also

For more about pressure ulcers, visit the Critical Care Nurse website, www.ccnonline.org, and read the article by Armour-Burton et al, “The Healthy Skin Project: Changing Nursing Practice to Prevent and Treat Hospital-Acquired Pressure Ulcers” (June 2013).

References


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Pressure Ulcer Management

Pressure Ulcer Incidence in Patients Wearing Nasal-Oral Versus Full-Face Noninvasive Ventilation Masks

By Marilyn Schallom, RN, PhD, CCNS, CCRN, Lisa Cracchiolo, BA, RRT, AE-C, Antoinette Falker, RN, DNP, CCNS-BC, Jennifer Foster, RN, BSN, CNRN, CCRN, JoAnn Hager, RN, BSN, CWOCN, Tamara Morehouse, RN, BSN, CWOCN, Peggy Watts, RRT, MS, Linda Weems, BA, RRT, and Marin Kollef, MD

Notice to CE enrollees:
A closed-book, multiple-choice examination following this article tests your understanding of the following objectives:
1. Explain the importance of checking for pressure ulcers.
2. Identify areas of high risk for skin breakdown.
3. Enumerate advantages of wearing a full-face mask.

To read this article and take the CE test online, visit www.ajcconline.org and click “CE Articles in This Issue.” No CE test fee for AACN members.

Background
Device-related pressure ulcers from non-invasive ventilation masks alter skin integrity and cause patients discomfort.

Objective
To examine the incidence, location, and stage of pressure ulcers and patients’ comfort with a nasal-oral mask compared with a full-face mask.

Methods
A before-after study of a convenience sample of patients with noninvasive ventilation orders in 5 intensive care units was conducted. Two groups of 100 patients each received either the nasal-oral mask or the full-face mask. Skin was assessed before the mask was applied and every 12 hours after that or upon mask removal. Comfort levels were assessed every 12 hours on a Likert scale of 1 to 5 (1, most comfortable).

Results
A pressure ulcer developed in 20% of patients in the nasal-oral mask group and 2% of patients in the full-face mask group (P < .001). Comfort scores were significantly lower (more comfortable) with the full-face mask (mean [SD], 1.9 [1.1]) than with the nasal-oral mask (mean [SD], 2.7 [1.2], P < .001). Neither mean hours worn nor percentage adherence differed significantly: 28.9 (SD, 27.2) hours and 92% for full-face mask and 25 (SD, 20.7) and 92% for nasal-oral mask. No patients who had a pressure ulcer develop with the nasal-oral mask had a pressure ulcer develop with the full-face mask.

Conclusion
The full-face mask resulted in significantly fewer pressure ulcers and was more comfortable for patients. The full-face mask is a reasonable alternative to traditional nasal-oral masks for patients receiving noninvasive ventilation. (American Journal of Critical Care. 2015;24:349-357)
Noninvasive ventilation is the application of positive pressure via the upper respiratory tract for the purpose of augmenting alveolar ventilation and respiratory support. The goal of noninvasive ventilation is to relieve symptoms associated with hypoventilation, exacerbation of chronic obstructive pulmonary disease, or impending respiratory failure; enhance gas exchange; maximize patients’ comfort; and avoid intubation and invasive ventilation. Use of noninvasive ventilation is associated with device-related development of pressure ulcers under the mask. Published rates for the incidence of facial pressure ulcers associated with noninvasive ventilation masks range from 10% to 31%. Identification of device-related pressure ulcers, such as those associated with noninvasive ventilation masks, is becoming more common.

No research related to interventions to reduce the incidence or severity of pressure ulcers associated with noninvasive ventilation was found. However, several non–research-based recommendations were found in the literature. The Minnesota Hospital Association and recently the National Pressure Ulcer Advisory Panel (NPUAP) recommended consideration of a wound dressing such as a transparent film, silicones, thin foams, or hydrocolloids to reduce friction and shear to prevent pressure ulcers. Periodic repositioning of the mask, alternating 2 different types of masks, or interruptions of 10 minutes as tolerated are also recommended to promote blood flow to the tissues. Many patients in intensive care units (ICUs) cannot tolerate even brief interruptions in noninvasive ventilation therapy. Continuous positive airway pressure delivered via helmets and nasal prongs may also be used because of skin issues. However, the use of a helmet in adult volunteers resulted in rebreathing of carbon dioxide.

A full facial mask has the potential for greater redistribution of pressure because it covers the forehead and a larger area of the cheek/side of face than other masks. Lemyze et al switched patients to the full-face mask when patients had painful skin breakdown or mask intolerance. Patients switched to use of the full-face mask had significantly fewer pressure ulcers develop without a protective dressing. In our ICUs, we observed stage III and IV pressure ulcers as well as deep tissue injury with a nasal-oral mask. The objective of this study was to examine the incidence, location, and stage of pressure ulcers and patients’ comfort with a nasal-oral mask (Performtrak, Respironics, Philips Healthcare) compared with a full-face mask (Performax, Respironics, Philips Healthcare). Secondary outcomes included length of time on noninvasive ventilation, need for invasive ventilation, and ICU and hospital lengths of stay.

Methods
A before-after comparison study was conducted in 5 ICUs (111 ICU beds) at a university-affiliated medical center. The institutional review board granted approval for delayed consent because of the emergent nature of noninvasive ventilation. Enrollment of patients and data collection began immediately after screening of inclusion/exclusion criteria. Once the patient’s condition was stabilized, during family visitation or during a family telephone discussion, the patient, the patient’s legally authorized representative, or both were provided with study information. If consent was obtained, data collection continued. If consent was not obtained, all data that had been collected were destroyed.

Education
Before the start of the study, the coprimary investigators (M.S., L.C.) spent 6 weeks training all

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Marilyn Schallom is a clinical nurse specialist and research scientist in the Department of Research, Lisa Cracchiolo and Linda Weems are registered respiratory therapists and supervisors in the Respiratory Care Services Department, Antoinette Falke is a clinical nurse specialist for trauma, acute care surgery, and bariatrics, Jennifer Foster is a nurse educator in the neuroscience intensive care unit, JoAnn Hager is a certified wound/ostomy/continence nurse, Tamara Morehouse is a certified wound care nurse with the wound/ostomy/continence team, and Peggy Watts is a registered respiratory therapist and manager in the Respiratory Care Services Department at Barnes-Jewish Hospital, St Louis, Missouri. Marin Kollef is a professor of medicine at Washington University School of Medicine, St Louis, Missouri.

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respiratory therapists and ICU-registered nurses. Education tools included a PowerPoint presentation and demonstration. Education focused on proper mask size and fit with acceptable leak parameters, study criteria, identification of pressure ulcers, comfort scale, and data collection. Education on the proper application of both noninvasive ventilation masks included selection of proper mask size and fit. Therapists and nurses practiced application and proper adjustments of the masks on a mannequin. Nurses and therapists were also educated on visual skin assessment for redness or discoloration and application of light touch for the identification of blanchable versus nonblanchable redness or discoloration. Staging of pressure ulcers by using NPUAP staging guidelines was reviewed. Additionally, the hospital uses descriptive wording based on NPUAP staging in the electronic medical record. Therefore, all nurses were familiar with assessment and documentation of changes in skin integrity. During the first month of data collection, the coprimary investigators worked together with team members to ensure that all team members were collecting data correctly and assessing skin correctly. During this time period, the team members had 100% agreement on skin assessment. The team members remained constant throughout both phases of the study: 2 respiratory therapists and 5 registered nurses. If questions arose regarding skin integrity or pressure ulcer stage, a primary investigator was contacted for consultation and agreement was reached for final documentation.

Sample

A convenience sample of 200 patients with noninvasive ventilation orders was recruited. No previous studies with the primary outcome measure of pressure ulcers were available for a power analysis to determine sample size. The first group of 100 patients received noninvasive ventilation initiated with the nasal-oral mask. The second group had noninvasive ventilation initiated with a full-face mask. Both the full-face mask and the nasal-oral mask are made of the same material, and securing straps for each are made of the same material.

Before a noninvasive ventilation mask was applied, the patient’s skin was assessed to ensure that no pressure ulcers were present on the bridge of the nose, cheeks, or forehead. The mask was then applied and noninvasive ventilation was initiated by the respiratory therapist. Within 1 hour of initiation of noninvasive ventilation, patients were assessed for inclusion in and exclusion from the study. Inclusion criteria were noninvasive ventilation order and age at least 18 years and less than 90 years. Exclusion criteria included existing redness or pressure ulcer, stage I or higher, on facial areas that would be under the mask, history of glaucoma or eye surgery within the past 6 weeks, use of home equipment for noninvasive ventilation in the hospital, and women who were pregnant.

Data Collection and Procedures

Skin integrity was assessed when noninvasive ventilation was started and documented by the research team member or ICU nurse. Patients’ skin was assessed and documented every morning by a member of the study team and every evening by the bedside nurse. Skin was assessed by briefly removing the noninvasive ventilation mask for inspection of the face, forehead, and bridge of the nose for any redness or pressure ulcer. In addition, with any repositioning, removal, and or reapplication of the mask, skin assessment was completed by the bedside nurse and respiratory therapist. Patients who had a nonblanchable redness or discoloration, a stage I pressure ulcer, or any higher stage pressure ulcer develop were immediately transitioned to the alternative noninvasive ventilation mask. Patients switched to the alternative mask were followed up for pressure ulcers but were not included in any further data collection or data analysis. Skin assessment continued with the new mask to ensure no further development of any pressure ulcers and for monitoring of all pressure ulcers until they healed or the patient died. Other reasons for switching to the alternative mask included patients’ refusal or intolerance of the initial mask. Patients were removed from the study at this point.

Within the first hour of wear, the comfort level was obtained and documented by the respiratory therapist. Patients were asked to assess the level of comfort with the mask. The comfort scale consisted of a 5-point Likert visual analogue scale: 1 = comfortable with noninvasive ventilation mask, 2 = mild discomfort but will continue with the mask, 3 = moderate discomfort but will continue with the mask, 4 = severe discomfort with the mask, and 5 = intolerable discomfort with the mask.

The first 100 patients received noninvasive ventilation initiated with the nasal-oral mask, the second with the full-face mask.
Mean time to pressure ulcer development was 28.4 hours for the nasal-oral mask phase versus 61.37 hours for the full-face mask phase.

Results
 Patients were enrolled from May 2012 to May 2013. A total of 1204 patients with orders for noninvasive ventilation were screened; 357 were excluded in the nasal-oral mask phase and 647 were excluded in the full-face mask phase (Figure 1). One hundred patients were enrolled and provided consent in each phase. Mean age, sex, race, admitting diagnosis category, APACHE II score, and indication for noninvasive ventilation were not significantly different between phases (Table 1). Skin observations and comfort assessments were not significantly different between groups with a mean (SD) number of 2.95 (2.03) skin observations and comfort assessments in the nasal-oral mask phase and a mean (SD) of 2.87 (2.08) in the full-face mask phase ($P = .78$).

Primary Outcome: Pressure Ulcer Incidence, Stage, and Location
 Pressure ulcer development differed significantly ($P < .001$) between the 2 masks. Twenty percent of patients in the nasal-oral mask phase had a pressure ulcer develop on the nose or the face area under the mask. Sixteen pressure ulcers were stage I, and 4 were stage II. Two percent of patients in the full-face mask phase had a pressure ulcer develop: 1 stage II pressure ulcer on the face area under the mask and 1 deep tissue injury of the scalp under the strap. The distribution of pressure ulcer locations is shown in Figure 2. Because of the skin being assessed each time the mask was removed, time to detection of pressure ulcers varied. Time for pressure ulcer development ranged from 1.25 hours to 74 hours with a mean (SD) of 28.4 (19.46) hours for the nasal-oral phase and 24.75 to 98 hours with a mean (SD) of 61.37 (51.79) hours for the 2 pressure ulcers in the full-face phase. Identification of pressure ulcers during the nasal-oral mask phase occurred throughout the data collection period, with 3 to 6 pressure ulcers identified each month.

Secondary Outcome: Comfort Score
 Patients in the full-face mask phase reported a significantly lower ($P < .001$) comfort score (mean [SD], 1.9 [1.1]), representing mild discomfort, compared with the nasal-oral mask phase (2.7 [1.2]).

Wear Time and Other Outcomes
 Wear time and adherence were not significantly different between phases. Mean wear time was greater than 24 hours and adherence was greater than 90% with both masks (Table 2). Total days of noninvasive ventilation and subsequent use of noninvasive ventilation were significantly higher for the nasal-oral mask phase because patients were switched to the full-face mask when a pressure ulcer was identified. Days of mechanical ventilation and ICU and hospital length of stay did not differ significantly between phases (Table 2). The reason for
Figure 1: Participant flow.

Excluded (n = 357)
- Glaucoma, recent eye surgery (4)
- Nose abrasion, pressure ulcer (9)
- Started in emergency department or other area (15)
- Refusal to wear (12)
- Home unit (79)
- Nights only (55)
- Missed on night shift (53)
- Standby (33)
- Wore for 4 hours or less (25)
- Declined participation (11)
- Unable to consent (11)
- Started on NO (not applicable)
- Use only as needed (11)
- Nasal pillow continuous positive airway pressure (15)
- High-flow nasal cannula (2)
- Comfort care (6)
- Intubated (4)
- Foam dressing applied (8)
- Not English speaking (1)
- Prisoner or ward of state (1)
- Mask did not fit (1)
- > 90 years old (1)
- Physician refused NO mask (0)

Excluded (n = 647)
- Glaucoma, recent eye surgery (7)
- Nose abrasion, pressure ulcer (2)
- Started in emergency department or other area (29)
- Refusal to wear (25)
- Home unit (113)
- Nights only (71)
- Missed on night shift (14)
- Standby (63)
- Wore for 4 hours or less (33)
- Declined participation (6)
- Unable to consent (19)
- Started on NO (228)
- Use only as needed (9)
- Nasal pillow continuous positive airway pressure (5)
- High-flow nasal cannula (0)
- Comfort care (5)
- Intubated (7)
- Foam dressing applied (2)
- Not English speaking (1)
- Prisoner or ward of state (3)
- Mask did not fit (1)
- > 90 years old (1)
- Physician refused FF mask (3)

Received NO mask intervention (n = 100)
- Lost to follow-up (0)
  - Discontinued intervention (11)
    - Refusal of noninvasive ventilation (6)
    - Request to change mask (1)
    - Poor fit, changed to FF (1)
    - Foam dressing applied for patient’s complaint of discomfort (3)
- Analyzed (n = 100)

Received FF mask intervention (n = 100)
- Lost to follow-up (0)
  - Discontinued intervention (2)
    - Refusal of noninvasive ventilation (1)
    - Changed to NO mask for epoprostenol inhalation (1)
- Analyzed (n = 100)
study exit was significantly different: discontinuation of noninvasive ventilation was higher in the full-face mask phase and pressure ulcer development was higher in the nasal-oral mask phase (Table 3). Intubation rates did not differ significantly between phases.

**Discussion**

With the comparison of the 2 noninvasive ventilation masks, patients in the full-face mask group had significantly fewer pressure ulcers develop and reported being more comfortable than the nasal-oral mask patients. Our findings are consistent with the results reported by Lemyze and colleagues, who used the full-face mask when patients had painful skin breakdown or nasal-oral mask intolerance. They reported that patients switched to the full-face mask had significantly fewer pressure ulcers develop. In this study, we identified pressure ulcer development as early as 1.25 hours after nasal-oral mask application. Because of the need for noninvasive ventilation for a mean of 25 to 28 hours with 90% adherence, patients are clearly at high risk for pressure ulcers related to masks used for noninvasive ventilation. The full-face mask is a reasonable alternative to traditional nasal-oral masks to decrease the incidence of pressure ulcers related to the noninvasive ventilation mask because of the full-face mask’s larger surface area for pressure distribution. In addition, high-flow therapies such as administration of heated humidified air via a high-flow nasal cannula or noninvasive ventilation nasal pillows may provide an additional alternative to noninvasive ventilation masks with less risk for pressure ulcers. However, further research on these devices is needed, particularly comparison of the outcomes related to pressure ulcers, oxygenation, and ventilation, such as prevention of invasive ventilation.

During education of nurses and therapists, concerns were voiced regarding patients’ discomfort and the potential for dry eyes. However, neither of these concerns were observed. The finding that the full-face mask was more comfortable, as indicated by patient-reported scores, was not expected by bedside clinicians. No patients complained of dry eyes.

This study had several limitations. First this was a nonrandomized before-after study. Although the participants’ characteristics were not significantly different, there may have been an unknown factor that led to lower pressure ulcer rates and comfort scores during the full-face mask phase. Another major limitation is the large number of patients who were missed during the full-face mask phase. Because the institution’s default was to initiate the nasal-oral mask on all patients, many ICU patients were not started in the study during the full-face mask phase. A total of 228 patients were not enrolled in the study because the noninvasive ventilation was started with the nasal-oral mask during the full-face mask phase. This led to a longer phase of data collection for the full-face mask. The large number of missed enrollment opportunities may have led to sample bias. Also, although members of the study team remained consistent throughout the study, a large number of bedside nurses and therapists conducted the evening assessments. To ensure
intervention fidelity, the study team had daily contact with nurses and therapists to answer questions and verify assessments. A final limitation is that the full-face mask cannot be worn by patients with a known history of glaucoma or who have had eye surgery in the past 6 weeks. Although the ventilator pressures are directed toward the mouth and nose, these patients were excluded because of the potential for increased ocular pressure as the mask covers the eyes.

Further research is needed to verify these results with a larger sample in a randomized study. In addition, research is needed on the use of various noninvasive ventilation masks with application of transparent film, silicone, thin foam, or hydrocolloid dressings to facial contact points to reduce friction and shear as recommended by the NPUAP.

Implications for Practice

For a variety of reasons, ICU patients may require noninvasive ventilation for greater than 24 hours of continuous wear. Development of pressure ulcers is a major concern with this extended wear and minimal removal time for pressure relief. We found that the use of a full-face mask that distributes the pressure to a larger surface area resulted in significantly fewer pressure ulcers and was more comfortable for patients. Frequent assessment of a patient’s skin is important to detect stage I pressure ulcers promptly and prevent the development of higher stages of pressure ulcers. Assessment of the skin beneath a noninvasive ventilation mask every 12 hours and whenever the mask is removed can lead to early identification of skin changes. The full-face mask is a reasonable alternative to traditional nasal-oral masks to decrease the incidence of pressure ulcers related to noninvasive ventilation masks.

ACKNOWLEDGMENTS

The authors thank all of the respiratory therapists and nurses who identified and initiated patients in the study and assessed and documented the data. We also thank respiratory therapy and nursing leadership for their support of this study. Without the assistance and support of therapists, nurses, and leaders, this study would not have been possible.

FINANCIAL DISCLOSURES

Marin Kollef’s efforts for the study were supported by the Barnes-Jewish Hospital Foundation.

REFERENCES

5. Schettino G, Altobelli N, Kacmarek RM. Noninvasive

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**Table 2**

<table>
<thead>
<tr>
<th>Resulta</th>
<th>Nasal-oral mask</th>
<th>Full-face mask</th>
<th>P</th>
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<tr>
<td>Total hours worn</td>
<td>25.01 (20.78)</td>
<td>28.89 (27.18)</td>
<td>.26</td>
</tr>
<tr>
<td>Adherence, %</td>
<td>92.11 (12.5)</td>
<td>91.84 (12.13)</td>
<td>.88</td>
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<tr>
<td>Total days of noninvasive ventilation</td>
<td>4.45 (4.77)</td>
<td>2.15 (1.64)</td>
<td>&lt;.001</td>
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<td>Had subsequent days of noninvasive ventilation, %</td>
<td>39</td>
<td>24</td>
<td>.02</td>
</tr>
<tr>
<td>Total days of mechanical ventilation</td>
<td>7.21 (15.2)</td>
<td>5.04 (8.78)</td>
<td>.22</td>
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<tr>
<td>Days in intensive care unit</td>
<td>12.99 (15.1)</td>
<td>12.10 (22.3)</td>
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<tr>
<td>Days in hospital</td>
<td>21.77 (19.97)</td>
<td>22.23 (26.41)</td>
<td>.89</td>
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* Values in second and third columns are mean (SD) unless otherwise indicated in this column.

**Table 3**

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<th>Reason</th>
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<th>Nasal-oral mask</th>
<th>Full-face mask</th>
<th>P</th>
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<td>Discharge from intensive care unit</td>
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<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discontinuance of noninvasive ventilation or wearing mask &lt; 60% of time</td>
<td>52</td>
<td>72</td>
<td>.005</td>
<td></td>
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<td>Refusal of noninvasive ventilation</td>
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<td>1</td>
<td>.12</td>
<td></td>
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<tr>
<td>Pressure ulcer</td>
<td>20</td>
<td>1</td>
<td>&lt;.001</td>
<td></td>
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<td>Death</td>
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<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Intubated</td>
<td>15</td>
<td>22</td>
<td>.27</td>
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<td>Other (see Figure 1)</td>
<td>5</td>
<td>2</td>
<td>.44</td>
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**CE Test**  
**Test ID A1524043: Pressure Ulcer Incidence in Patients Wearing Nasal-Oral Versus Full-Face Noninvasive Ventilation Masks**

**Learning objectives:**  
1. Explain the importance of checking for pressure ulcers.  
2. Identify areas of high risk for skin breakdown.  
3. Enumerate advantages of wearing a full-face mask.

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<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
<th>Answer</th>
</tr>
</thead>
</table>
| 1. Noninvasive ventilation is the application of oxygen via which of the following? | a. Positive pressure  
b. Negative pressure  
c. Deep pressure  
d. Light pressure | d. Light pressure |
| 2. Why shouldn’t an oxygen helmet be used for patients with skin issues? | a. It causes skin breakdown on the scalp.  
b. It delivers a less accurate dose of oxygen.  
c. It results in rebreathing of carbon dioxide.  
d. It causes more pressure on the cranium. | d. It causes more pressure on the cranium. |
| 3. Which of the following was used to assess a patient’s level of comfort with the mask? | a. Pain Scale  
b. Wong-Baker Scale  
c. Critical-Care Pain Observation Tool  
d. Likert Scale | b. Wong-Baker Scale |
| 4. For this study, adherence was defined as which of the following? | a. Compliance with mask wear  
b. Wear time divided by total number of hours  
c. Verbal consent to use mask  
d. Written consent to use mask | c. Verbal consent to use mask |
| 5. How many patients developed pressure ulcers among those who used an nasal-oral mask? | a. 20%  
b. 40%  
c. 60%  
d. 10% | a. 20% |
| 6. How soon did patients develop pressure ulcers after application of the nasal-oral mask? | a. 2.25 hours  
b. 6 hours  
c. 5 hours  
d. 1.25 hours | c. 6 hours |
| 7. During education, which of the following concerns was expressed by nurses but not seen in patients during the study? | a. Itchy eyes  
b. Dry nose  
c. Dry eyes  
d. Dry mouth | a. Dry eyes |
| 8. How often should assessment of the skin beneath a noninvasive mask be done? | a. Every 6 hours  
b. Every 4 hours  
c. Every 12 hours  
d. Every 8 hours | a. Every 6 hours |
| 9. Which of the following is recommended to promote blood flow to the tissues when patients are using respiratory masks? | a. Use of a ventilator  
b. Increasing the oxygen flow  
c. Decreasing the oxygen flow  
d. Periodic repositioning of the mask | c. Decreasing the oxygen flow |
| 10. Which of the following groups of patients reported greater comfort? | a. Patients using a nasal-oral mask  
b. Patients who were intubated  
c. Patients on respiratory treatments  
d. Patients using a full-face mask | b. Patients who were intubated |
| 11. Which of the following is an alternative to noninvasive masks? | a. Low-flow nasal cannula  
b. Oxygen tent  
c. Nasal pillows  
d. Nasal-oral mask | d. Oxygen tent |
| 12. Which of the following facial areas had the highest rate of skin breakdown associated with the noninvasive masks? | a. Forehead  
b. Nasal bridge  
c. Cheek  
d. Lips | a. Forehead |

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**Program evaluation**

<table>
<thead>
<tr>
<th>Objective</th>
<th>met</th>
<th>not met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explain the importance of checking for pressure ulcers.</td>
<td>☑️</td>
<td>☐️</td>
</tr>
<tr>
<td>2. Identify areas of high risk for skin breakdown.</td>
<td>☑️</td>
<td>☐️</td>
</tr>
<tr>
<td>3. Enumerate advantages of wearing a full-face mask.</td>
<td>☑️</td>
<td>☐️</td>
</tr>
</tbody>
</table>

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The American Association of Critical-Care Nurses is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center’s Commission on Accreditation. AACN has been approved as a provider of continuing education in nursing by the State Boards of Nursing of Alabama (#ABNP0062), California (#CEP1036), and Louisiana (#LSBN12). AACN programming meets the standards for most other states requiring mandatory continuing education credit for relicensure.
A cross acute care settings, noninvasive ventilation is commonly implemented to attenuate the effects of respiratory insufficiency or failure. Despite the varied benefits of noninvasive ventilation, an untoward consequence of this therapy is the genesis of device-related facial pressure ulcers.

It is estimated that nearly one-third of patients who require noninvasive ventilation develop a facial pressure ulcer due to a variety of factors associated with the patient's condition and the failure to properly apply noninvasive ventilation masks onto the patient's face. Although recommendations for the prevention of device-related pressure ulcers have been published, there is limited evidence on the incidence of device-related pressure ulcers between the 2 most common types of masks to deliver noninvasive ventilation: full-face and nasal-oral masks.

In this study, the authors sought to understand if there were differences in pressure injury incidence and severity, as well as perceived comfort and adherence times between critically ill patients who had a full-face mask compared to those who had a nasal-oral mask applied for noninvasive ventilation. Using a before-and-after study design, the authors recruited 200 critically ill adults (aged 18-90 years) who had noninvasive ventilation orders. Based on the timing of their enrollment, participants received either the full-face mask (n=100) or nasal-oral mask (n=100) for noninvasive ventilation therapy. Skin integrity was assessed prior to the application of a mask, and then every 12 hours, and each time the mask was removed. Comfort levels and adherence times (amount of time the mask was worn divided by the total number of hours) were documented every 12 hours. Critically ill patients were excluded if they were more than 90 years old, or had an existing facial pressure ulcer, history of glaucoma or ophthalmic surgery within 6 weeks, used their own noninvasive ventilation equipment in the hospital, or were pregnant.

The occurrence of facial pressure ulcers differs by the type of mask used for noninvasive ventilation. In this sample of critically ill patients, the authors report that a higher proportion of critically ill patients with the nasal-oral mask developed a device-related facial pressure ulcer when compared with those who used the full-face mask. The full-face mask was also perceived as more comfortable compared with the nasal-oral mask in this sample. However, the authors found no statistically significant differences in the adherence times between the groups.
Information From the Authors

Marilyn Schallom, RN, PhD, CCNS, CCRN, lead author on this article provides additional information about the study. Regarding her motivation for conducting this study, she says, “Working as a clinical nurse specialist in the surgical intensive care unit, I was part of a team that was charged to reduce pressure ulcers in critically ill patients. We identified device-related facial pressure ulcers as a significant contributor to our pressure ulcer rates.”

According to Schallom, the problem of device-related pressure ulcers transects multiple populations of critically ill patients. Prior to conducting this study, Schallom and her colleagues implemented a protective dressing protocol aimed at reducing the incidence of device-related pressure ulcers, which did not effectively deter the progression of worsening tissue injury associated with noninvasive ventilation. She says, “Whereas the need for noninvasive ventilation varied between populations of critically ill patients, the problem of device-related pressure ulcers from noninvasive ventilation is universal.”

To address the complex problem of device-related pressure ulcers, a multidisciplinary approach was needed. Schallom adds, “When you choose to study a problem that is significant to your patients, others will want to collaborate and will strengthen the study.” She continues, “As nurses, we are aware of the clinically relevant problems that we encounter every day and, through multidisciplinary partnerships, nurses can address complex problems to improve outcomes for patients.”

Implications for Practice

The project findings confirm the differences in the occurrence of device-related pressure ulcers and comfort by the type of mask used to provide noninvasive ventilation. In their study, Schallom and co-authors note that the full-face mask distributes the mask’s pressure across a larger surface area resulting in significantly lower occurrence of device-related pressure ulcers and more comfort.

She says because of the severity of their critical illnesses and need for vasoactive therapies, patients who require noninvasive ventilation are at risk for altered skin integrity and device-related pressure ulcers. The full mask is a reasonable alternative to the traditional nasal-oral mask to decrease device-related pressure ulcer formation and reduce discomfort.

Schallom recommends that readers of the American Journal of Critical Care frequently and routinely assess for device-related pressure ulcers among patients who receive noninvasive ventilation across acute care and community settings.

She advises, “Every critically ill patient receiving noninvasive ventilation is at risk for a device-related pressure ulcer. Pressure ulcer formation can occur within 24 hours of the initiation of noninvasive ventilation and the prevention of device-related pressure ulcers requires frequent assessments of skin integrity.”

Discussion Points

A. Description of the Study
   - What are the major concepts of the study?
   - What is the purpose of the study?

B. Literature Evaluation
   - What are recommended practices supported by the National Pressure Ulcer Advisory Panel?
   - What is the state of science on the type of mask used to deliver noninvasive ventilation and the occurrence of device-related pressure ulcers?

C. Sample
   - What patients were eligible to participate in this study?
   - Why do you suspect patients with glaucoma, recent ophthalmic surgery, and women who were pregnant were excluded from this study?

D. Methods and Design
   - What are the benefits of using a before-and-after research design?
   - How did the authors evaluate for the presence of a device-related pressure ulcer?

E. Results
   - What were the major findings of this project?
   - How can you use the findings of this project to improve the quality of your nursing care?
Telemetry monitoring is a powerful tool for real-time monitoring of heart rhythm. Telemetry beds are limited in number and expensive; therefore, their use should be evidence based. The 2004 American Heart Association (AHA) practice standards for electrocardiographic (ECG) monitoring are often not followed and rigorous criteria for inpatient telemetry admissions are often not systematically used, resulting in overcrowding in emergency departments and inpatient monitored beds (Table 1). Monitored beds are often occupied by patients who require only frequent nursing care rather than cardiac monitoring. Few studies have been done to determine whether inpatient telemetry monitoring is beneficial and accurately confirms the initial clinical impression.

Table 1
2004 American Heart Association practice standards for electrocardiographic monitoring in hospital settings

<table>
<thead>
<tr>
<th>Class</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>All patients at significant risk of an immediate, life-threatening arrhythmia. Cardiac monitoring is indicated in most, if not all, patients in this group.</td>
<td>Cardiac arrest; early phase of acute coronary syndrome (ACS); unstable ACS/newly diagnosed high-risk coronary lesions; acute heart failure/pulmonary edema; Atrioventricular block; arrhythmias complicating Wolff-Parkinson-White syndrome; long QT syndrome and ventricular arrhythmias; hemodynamically unstable arrhythmias in children/adults; Procedures requiring conscious sedation or anesthesia; cardiac surgery; nonurgent percutaneous coronary intervention (PCI) with complications; implantation of automatic defibrillator/pacemaker lead or pacemaker dependent; temporary pacemaker or transcutaneous pacing pads; intra-aortic balloon counterpulsation</td>
</tr>
<tr>
<td>II</td>
<td>Cardiac monitoring may be of benefit in some patients but is not considered essential for all. Cardiac monitoring often takes place in intermediate care (telemetry) unit.</td>
<td>Postacute myocardial infarction; chest pain syndromes; uncomplicated, nonurgent PCI; subacute heart failure; syncope evaluation; Arrhythmias that cause discomfort in patients with do-not-resuscitate orders; Antiarrhythmic drug or dose adjustment for rate control with chronic atrial tachyarrhythmias; Implantation of pacemaker lead or not pacemaker dependent; uncomplicated ablation; routine coronary angiography</td>
</tr>
<tr>
<td>III</td>
<td>Cardiac monitoring is helpful in clinical management but it is not expected to save lives. Cardiac monitoring is not indicated because a patient’s risk of a serious event is so low that monitoring has no therapeutic benefit.</td>
<td>Obstetric patients without heart disease; Permanent rate-controlled atrial fibrillation; stable patients with chronic venricular beats; Postoperative patients at low risk for arrhythmias; Hemodialysis (except for patients with other Class I or II indications, or those undergoing dialysis in the hospital setting)</td>
</tr>
</tbody>
</table>

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©2015 American Association of Critical-Care Nurses
doi: http://dx.doi.org/10.4037/ajcc2015270

Clinical Evidence Review

A regular feature of the American Journal of Critical Care, Clinical Evidence Review unveils available scientific evidence to answer questions faced in contemporary clinical practice. It is intended to support, refute, or shed light on health care practices where little evidence exists. To send an eLetter or to contribute to an online discussion about this article, visit www.ajcconline.org and click “Respond to This Article” on either the full-text or PDF view of the article. We welcome letters regarding this feature and encourage the submission of questions for future review.
facilitating ongoing treatment plans.3,10 The PICO (problem, intervention, control, outcome) question crafted for this review was, “For hospitalized adults, what criteria are used for admission to a telemetry unit and/or telemetry monitoring?”

Search Methods

A comprehensive search strategy was used to identify evidence reported between January 2000 and August 2014 or open search if few results were obtained. The Figure outlines the databases, key search terms, and relevant articles matching the inclusion and exclusion criteria. The final evidence matrix included 1 expert consensus statement,6 3 retrospective studies,2,7,11 2 prospective observational studies5,10 and 1 randomized clinical trial9 (Tables 2 and 3).

Figure Preferred Reporting Items for Systematic Reviews (PRISMA) diagram of criteria for admission to telemetry unit.

Table 2
American Association of Critical-Care Nurses evidence-leveling system

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>No. of relevant articles</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Meta-analysis of multiple controlled studies or metasynthesis of qualitative studies with results that consistently support a specific action, intervention, or treatment</td>
<td>6</td>
<td>2,5,7,9,10,11</td>
</tr>
<tr>
<td>B</td>
<td>Well-designed controlled studies, both randomized and nonrandomized, with results that consistently support a specific action, intervention, or treatment</td>
<td>6</td>
<td>2,5,7,9,10,11</td>
</tr>
<tr>
<td>C</td>
<td>Qualitative studies, descriptive or correlational studies, integrative reviews, systematic reviews, or randomized controlled trials with inconsistent results</td>
<td>2</td>
<td>5,7,9,10,11</td>
</tr>
<tr>
<td>D</td>
<td>Peer-reviewed professional organizational standards, with clinical studies to support recommendations</td>
<td>2</td>
<td>5,7,9,10,11</td>
</tr>
<tr>
<td>E</td>
<td>Theory-based evidence from expert opinion or multiple case reports</td>
<td>2</td>
<td>5,7,9,10,11</td>
</tr>
<tr>
<td>M</td>
<td>Manufacturer’s recommendation only</td>
<td>2</td>
<td>5,7,9,10,11</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2</td>
<td>5,7,9,10,11</td>
</tr>
</tbody>
</table>

6From Armola et al,7 with permission.

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Although the 2004 AHA practice standards were groundbreaking, few studies have validated their effectivenes. In most of the studies in this review, researchers reported that patients who had telemetry ordered did not meet class I and class II indications. Furthermore, arrhythmic events were infrequent and clinically insignificant. Table 4 shows common diagnoses used in ordering telemetry. These results suggest that the practice standards do not address several noncardiac conditions that physicians often monitor on telemetry units and thus may not apply to patients with primary medical diagnoses. For example, in a randomized controlled trial by Funk et al., 28.2% of patients admitted to cardiac units from 17 hospitals had a noncardiac primary diagnosis; these patients may not be appropriate for monitoring for arrhythmia, ischemia, and increased QT interval. Of the 7 diagnoses common to both hospital admission via the emergency department and telemetry unit admission, pulmonary disease and respiratory distress (ie, chronic obstructive pulmonary disease or pneumonia) are conditions without indications for ECG monitoring per AHA practice standards. Yet, patients are still admitted to telemetry units for these conditions. Causes for overmonitoring and undermonitoring may be lack of awareness and/or nonadherence to practice standards by clinicians, or a combination of other factors such as technology, equipment, and condition-specific.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Design and sample</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drew et al</td>
<td>Scientific consensus statement from multiple professional organizations</td>
<td>Provided guidelines for class I, II and III indications (Table 1), time frames, and strategies to improve diagnostic accuracy of cardiac arrhythmia, ischemia, and QT-interval monitoring in adults and children</td>
</tr>
<tr>
<td>Benjamin et al</td>
<td>Retrospective (N = 4) urban academic medical centers</td>
<td>Fewer than 1/3 telemetry days (in a 3-week period) did not meet American Heart Association (AHA) indications. Arrhythmia incidence on nonindicated days low (3.1/100 days of monitoring per nonindicated day); detected arrhythmias were clinically insignificant. Eliminating nonindicated days could save $53/patient day</td>
</tr>
<tr>
<td>Curry et al</td>
<td>Retrospective cohort (N = 236 admissions) to determine rate of events in “tele-indicated” vs “not indicated” patients (based on modified 1991 American College of Cardiology [ACC] practice standards)</td>
<td>29% admissions never met indications on any day; only 17% met on any day. 95% events (n = 162) occurred on 400 tele-indicated days; 5% occurred on 345 non-tele-indicated days (n = 9 minor events required no therapy)</td>
</tr>
<tr>
<td>Dhillon et al</td>
<td>Retrospective (N = 562) telemetry unit admission comparisons against modified electrocardiographic (ECG) monitoring guidelines (“telemetry indicated” vs “not indicated”)</td>
<td>Significantly more arrhythmia events in “telemetry indicated” vs “not indicated” group. No clinically significant arrhythmias required change in patient management in “not indicated” group</td>
</tr>
<tr>
<td>Falun et al</td>
<td>Prospective observational (N = 1194)</td>
<td>Most patients met class I (18%) or class II (71%) indications (vs 11% who met class III); high total adherence rate (89%). Arrhythmia event rate/change in patient management: Class I: 43%/25%; Class II: 28%/14%; Class III: 47%/29%. More accurate distribution of class I and class II indications using discharge rather than admission diagnoses</td>
</tr>
<tr>
<td>Funk et al</td>
<td>Multisite randomized controlled trial of 2744 observations (N = 1816) on adult cardiac units in 17 hospitals to evaluate implementation of AHA practice standards for ECG monitoring (28.2% of patients had noncardiac primary diagnosis)</td>
<td>Inappropriate monitoring included undermonitoring for ischemia and QTc prolongation, and overmonitoring for all 3 types, particularly arrhythmia monitoring: 99% with arrhythmia indication vs 85% with no indication; 35% with ischemia indications vs 26% with no indication; 21% with QT-interval indication vs 18% with no indication had QTc documentation</td>
</tr>
<tr>
<td>Najafi and Auerbach</td>
<td>Prospective observational (N = 100) noncardiac medical service patients</td>
<td>11% of patients met AHA class I indications. 10% had management changes due to telemetry events (9 diagnostic tests, 8 medication changes, 7 intravenous fluids, 2 transfers to critical care who did not meet criteria for class I). Concerns for patients’ condition deteriorating was reason for 50% telemetry use, although few patients had clinically meaningful cardiac events (4 patients who did not meet criteria for class I had a new atrial fibrillation/flutter develop)</td>
</tr>
</tbody>
</table>
formula calculations. Furthermore, a method to easily identify low-risk patients (class III) within the current AHA practice standards does not exist.

Other authors reviewed earlier publications for evidence of the need to monitor specific diagnoses. Five diagnoses were highlighted as having no evidence for telemetry monitoring (Table 5). Further research is needed for telemetry utilization and understanding nuances for overmonitoring and undermonitoring of cardiac and noncardiac patients. Research could further the validation and revision of current AHA practice standards and promote an evidence-based approach to clinical practice.

**Recommendations for Practice**

Most institutions and clinicians use the 2004 AHA practice standards to structure monitoring decisions. However, these practice standards are 11 years old and may need to be updated to address primary noncardiac conditions often monitored on telemetry units or patients often considered “low risk.” A stratification tool, coupled with telemetry guidelines and admission criteria, can increase efficient resource utilization and reduce unnecessary admissions and telemetry use. Goldman and colleagues developed the most widely studied risk stratification protocol for chest pain, stratifying patients with suspected acute coronary syndrome into high, moderate, low, and very low risk on the basis of 5 variables. Other tools include the Acute Cardiac Ischemia Time-Insensitive Predictive Instrument and Thrombolysis in Myocardial Infarction risk scores. The assessment of high-risk patients without the benefit of a risk stratification protocol may result in allocation of more high-risk patients to unmonitored beds. However, wide variability remains in management decisions and resource utilization via the use of risk stratification protocols.

### Table 4

**Diagnoses common to hospital admission through the emergency department and admissions to the telemetry unit**

<table>
<thead>
<tr>
<th>Common diagnoses of telemetry unit admissions</th>
<th>Top 10 diagnoses of hospital admissions via the emergency department</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Acute cerebrovascular disease</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>* Acute coronary syndrome</td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>* Arrhythmia</td>
<td>Chest pain</td>
</tr>
<tr>
<td>* Chest pain</td>
<td>* Atherosclerosis, other heart disease</td>
</tr>
<tr>
<td>* Congestive heart failure</td>
<td>Acute coronary syndrome</td>
</tr>
<tr>
<td>* Electrolyte disorders</td>
<td>Acute cerebrovascular disease</td>
</tr>
<tr>
<td>Febrile illness/sepsis</td>
<td>Chronic obstructive lung disease</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>* Arrhythmias</td>
</tr>
<tr>
<td>Pulmonary disease, respiratory distress (chronic obstructive pulmonary disease or pneumonia)</td>
<td>* Fluid and electrolyte disorders</td>
</tr>
<tr>
<td>* Syncope</td>
<td>Affective or mood disorders</td>
</tr>
</tbody>
</table>

### Table 5

**Clinical considerations**

1. Increase clinicians’ awareness of 2004 American Heart Association (AHA) practice standards.
2. Incorporate 2004 AHA practice standards into academic curriculum and continuing education, including nurses and emergency medicine staff.
3. Supplement existing 2004 AHA practice standards to reflect current practice environment, including indications, exclusion, and discharge criteria for telemetry monitoring, particularly for patients with noncardiac conditions.
4. Reduce telemetry overmonitoring and undermonitoring by adhering to specific indicated criteria to promote an evidence-based approach and safely reduce unnecessary testing, treatment, and health care costs.
5. Telemetry monitoring may not be indicated for the following diagnoses:
   - Minor blood transfusion (2 units or less of packed red blood cells)
   - Chest pain with normal or nonspecific electrocardiographic findings
   - Acute exacerbation of chronic obstructive pulmonary disease
   - Stable patients with anticoagulation for pulmonary embolism
   - Blunt chest trauma in the emergency department with normal electrocardiographic findings and blood pressure, and no dysrhythmias
6. Telemetry should not replace frequent observation and assessment of vital signs, nor should it influence nurse staffing levels.
7. Encourage nurses to review the need for telemetry on a daily basis and confer with interprofessional team to determine if the current patient diagnosis warrants continued monitoring.
8. Incorporate the use of simple risk-stratification instruments such as the Goldman risk assessment tool to ensure that telemetry is reserved for patients who receive the most benefit.
and tools. The threat of litigation represents a formidable obstacle to the widespread implementation of standardized risk-stratification methods and appropriate criteria for telemetry monitoring.

Another issue uncovered in this review is the monitoring of patients in deteriorating condition. These patients are often placed on telemetry simply to ensure frequent nurse surveillance, rather than for dysrhythmias that require ECG monitoring. Researchers in multiple studies have reported that widespread monitoring does not change medical management or produce a substantial survival benefit, even in cardiac arrest patients. (However, the high-risk subset of patients did show potential benefit.) The time and effort required to monitor “nonindicated” patients takes nurses away from other patients’ needs and caring for telemetry-indicated patients. Telemetry does not replace frequent observation and vital signs, nor should it be used to influence nurse-to-patient staffing ratios through inappropriate use. Overmonitoring increases the risk of artifacts and false alarms and the risk of their misinterpretation, and it also desensitizes monitor watchers, leading to missed meaningful alarms and errors in clinical management. Additional safety concerns include alert fatigue and interruptions that adversely affect patient care and outcomes. The overall clinical value of ECG monitoring is often overestimated and may lead both nurses and physicians to feel a false sense of security about monitoring of patients.

The simple recognition of low-risk patients not needing monitoring has both clinical and financial implications related to reduced adverse outcomes for patients, increased monitoring capacity, and effective use of limited resources. Clinicians must ensure consistency between initial symptoms and final diagnoses. Additionally, current patient diagnosis should be used to determine if telemetry monitoring is indicated each day. It must be noted that class II indications give clinicians the opportunity to examine and uniquely evaluate each patient to decide whether continued ECG monitoring is warranted. Some institutions have reexamined best evidence and enlisted the consensus of clinical experts to supplement the existing 2004 AHA practice standards to reflect the current practice environment and include populations not specially addressed. This work includes indications, exclusion criteria, and discharge criteria for telemetry monitoring. These supplements to practice may minimize ECG overmonitoring and undermonitoring, prevent overcrowding in the emergency department and ambulance diversion, and enhance clinical outcomes.

Determining appropriate admission, monitoring, and discharge of patients on telemetry units ultimately depends on interprofessional teamwork. Nurse involvement is key for the ideal functioning of modified criteria systems. Nurses play a pivotal role in reviewing the need for telemetry on a daily basis and consulting with the treatment team. Physicians are uniquely positioned to determine which patients need ECG monitoring, as supported by nursing staff, evidence-based tools and guidelines, and their own clinical expertise. Eight clinical considerations (Table 5) have the potential to influence decision making by nurse-physician interprofessional teams as they collaboratively provide the best possible care for patients, whether or not those patients are being monitored.

FINANCIAL DISCLOSURES
None reported.

eLetters
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REFERENCES

To purchase electronic or print reprints, contact American Association of Critical-Care Nurses, 101 Columbia, Aliso Viejo, CA 92656. Phone, (800) 899-1712 or (949) 362-2050 (ext 532); fax, (949) 362-2049; e-mail, reprints@aacn.org.
Scenario: This electrocardiogram (ECG) rhythm strip in lead II is from a 50-year-old woman who came to the emergency department after having fallen at home during an episode of syncope. She complained of “dizziness” prior to falling. She is currently prescribed escitalopram for depression, which she has taken for 5 years, and recently (2 days earlier) levofloxacin for bronchitis. She is a nonsmoker and has no other health conditions. Upon arrival, her vital signs were within normal limits.

Interpretation Questions:

1. Is the ECG properly calibrated (10 mm) and are leads properly placed? - Yes No NA
   If no, interpret cautiously.
2. Is this a sinus rhythm (one P wave preceding every QRS complex)? - Yes No NA
   If no, check for number of P waves in relation to QRS complexes.
3. Is the heart rate (R-R interval) normal (60-100 beats/min)? - Yes No NA
   If no, check for supra-ventricular or ventricular arrhythmias.
4. Is the QRS complex narrow (duration < 110 milliseconds [ms] in V1)? - Yes No NA
   If no, check for bundle branch blocks (BBBs), pacing, or ventricular arrhythmia.
5. Is the ST segment deviated (> 2 mm in V2-V3, or > 1 mm in other leads)? - Yes No NA
   If yes, check for similar deviations in contiguous cardiac territories.
6. Is the T wave inverted in relation to the QRS (> 0.5 mV)? - Yes No NA
   If yes, check for ST deviation or conduction abnormalities.
7. Is the QT interval lengthened (> 450 ms [women] or > 470 ms [men])? - Yes No NA
   If yes, check for ventricular arrhythmias or left ventricular hypertrophy.
8. Is R- or S-wave amplitude enlarged (S wave V1 + R wave V5 > 35 mm)? - Yes No NA
   If yes, check for axis deviation or other chamber hypertrophy criteria.

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©2015 American Association of Critical-Care Nurses doi: http://dx.doi.org/10.4037/ajcc2015712
Interpretation and Rationale

Normal sinus rhythm at 75 beats/min and QT interval prolongation. Given the recently prescribed levofloxacin and symptoms on arrival, it is fair to suspect acquired long QT syndrome (aLQTS).

Mechanism and Management

Channelopathies are caused by a malfunction in ion channels that regulate the movement of ions in and out of the myocardial cells during depolarization and repolarization. One channelopathy caused by medications affects cardiac repolarization by blocking the hERG channel during phase 3 of the action potential. This results in prolongation of the QT interval, termed long-QT syndrome (LQTS), and increases the risk for life-threatening arrhythmias.

LQTS can be either genetic or acquired, with the latter occurring from clinical therapies such as induced hypothermia, electrolyte disturbances (hypokalemia, or hypomagnesemia), or therapy with medications known to prolong the QT-interval. Importantly, both types of LQTS predispose patients to ventricular arrhythmias, in particular torsades de pointes (TdP), which can lead to ventricular fibrillation and sudden cardiac death.

The incidence of aLQTS is unknown, but it is estimated that more than 15,000 patients die of sudden cardiac death caused by aLQTS each year. This highlights the importance of immediate identification and actions to reverse aLQTS. Thus, the Food and Drug Administration has published recommended guidelines for the pharmaceutical industry on proper testing of new agents and their effect on the QT/QTc interval.

Identification of aLQTS following pharmacological therapy is challenging because more than 100 medications from varied classifications are associated with this syndrome. This patient was prescribed 2 medications known to lengthen the QT interval; escitalopram for depression, and levofloxacin to treat a respiratory infection. Levofloxacin appears to be the offending agent because the patient had taken escitalopram for years without symptoms suggestive of TdP (eg, syncope).

Fortunately, aLQTS is reversible following cessation and metabolization of the offending medication(s). This patient did not have a prior ECG for comparison, but changing her antibiotic immediately is warranted. She should be admitted to the hospital and her ECG continuously monitored until the QT interval returns to normal. If her QT interval remains prolonged, the escitalopram may also need to be carefully tapered and stopped. Referral to an electrophysiologist to rule out the genetic form of LQTS may be indicated if the QT interval remains lengthened. This patient should be advised to notify all health care providers about this incident and have this noted in her medical record.

Answers:
1. Yes, the ECG is properly calibrated (see calibration mark right side).
2. Yes, a P wave precedes every QRS complex.
3. Yes, the heart rate is normal at 75 beats/min.
4. Yes, the QRS complex is narrow at approximately 80 milliseconds (ms) duration
5. No, the ST segment is not deviated.
6. No, the T wave is upright.
7. Yes, the QT interval is lengthened; best measured using the 8th and 9th beats (see arrows above). In both beats, the start of the QRS complex lands very close to the dark line of the ECG grid, which marks the start of the QT interval. The T wave ends 12 small boxes (ie, ≈480 ms) from this point. Once corrected for heart rate using Bazett’s formula: QTc = QT / √ RR = 480 / √ 0.8 = 537 ms, the QT interval exceeds the normal limit of 450 for women.
8. Chamber hypertrophy cannot be assessed because Leads V₁ and V₅ are not shown.
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