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Nurse Estimation of Patients’ Pupil Size

Nurses’ Knowledge of Confidentiality Legislation

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NARROWING THE 17-YEAR RESEARCH TO PRACTICE GAP

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

Developing evidence to improve clinical practice and disseminating it to be used by clinicians to improve outcomes for individual patients is important. How long does it take to get evidence into practice? The standard refrain of “17 years to move evidence into practice” is repeated by researchers and clinicians alike with despair.1,2 Rather than accepting the inevitability of a long lag in translating research to the bedside, we believe it is worthwhile to examine the origin of the “17-year gap,” to scrutinize how it applies to interdisciplinary research in critical care, and to suggest ways to close that gap.

In March of 2001, the Institute of Medicine report Crossing the Quality Chasm3 stated, “It now takes an average of 17 years for new knowledge generated by randomized controlled trails to be incorporated into practice, and even then application is highly uneven.” Recently, the National Institutes of Health (NIH) strategic plan4 estimated that moving a new drug or medical device from conception to market takes 14 years and costs $2 billion. This includes 6.5 years for laboratory-based drug discovery and preclinical testing, 6 years for clinical trials of promising drug candidates, and 1.5 years for US Food and Drug Administration (FDA) approval of those that are brought to market.

The Investigative Process

Traditional clinical investigations proceed through multiple sequential steps. The process of planning a project, completing it, and disseminating results can be lengthy. A testable idea must be formulated and refined, and a research team assembled. Preliminary data may need to be gathered to guide a larger investigation. Permissions must be obtained and regulatory requirements met. Support must be obtained for essential resources such as personnel and supplies, which may entail seeking internal and external grant funding. Subjects must be enrolled, interventions delivered, data collected, and analyses performed. The final step for an individual research project entails dissemination of the findings through presentations and publications. Each of these steps is essential, and each takes time.

For pharmaceuticals, basic and preclinical research require a large investment of time and money. Only 5% of compounds initially screened in early research will move forward to market.4 Fortunately, not all critical care research involves pharmaceuticals, and not all critical care research requires lengthy accumulation of basic science and preclinical studies prior to development of clinically relevant research questions. Where FDA approval is not required, the process can move more quickly.

Assessing the Evidence

After research studies are completed, additional time is needed for the scientific community to amass
Few clinical questions are definitively answered in a short amount of time.

and assess evidence from multiple studies examining an area of intervention. In developing clinical guidelines that translate evidence to practice, both the quantity and quality of available evidence must be evaluated. GRADE (Grading of Recommendations Assessment, Development and Evaluation Working Group) and the American Association of Critical-Care Nurses (AACN) evidence-leveling hierarchy provide standardized approaches to developing clinical practice guidelines and rating the strength of recommendations. Few clinical questions are definitively answered in a short amount of time. More frequently, clinical questions are addressed in an iterative series of research studies, progressing from early observational studies to randomized controlled trials and meta-analyses. Guideline developers must make sense of a body of literature that includes diverse study designs, heterogeneous subject samples, differences in interventions, and a variety of outcome measures. New evidence may contradict or alter the interpretation of previous research, resulting in a need for continuous review and updating of existing guidelines.

Critical care research, including nursing and interdisciplinary research, regularly focuses on patient’s problems and interventions that do not involve drugs or devices and that have a rapid uptake in clinical practice. As an example, early mobility in the intensive care unit (ICU) has been the subject of research for less than a decade, but mobility protocols already have been widely implemented. Based on currently available evidence, mobility projects have been instituted in 11 ICUs through the AACN Clinical Scene Investigator (AACN CSI) Academy. Project summaries, final presentations, and implementation toolkits are posted at the AACN CSI website. Research in oral care, support of families in the ICU, infection control, communication, and optimizing team processes have had similar rapid translation to clinical practice and have been regularly updated as evidence evolves.

About the Authors

Cindy L. Munro is coeditor in chief of the American Journal of Critical Care. She is associate dean for research and innovation at the University of South Florida, College of Nursing, Tampa, Florida. Richard H. Savel is coeditor in chief of the American Journal of Critical Care. He is director, Adult Critical Care Services at Maimonides Medical Center and a professor of clinical medicine at the Albert Einstein College of Medicine, both in New York City.

National Initiatives

National initiatives are under way to narrow the research to practice gap. In 2012, the NIH established the National Center for Advancing Translational Sciences (NCATS). NCATS is responsible for accelerating the timeline for converting basic science research to testable clinical products (Type 1 translation) and from clinical research into practice (Type 2 translation). As a leader in translational science, NCATS focuses on the process of translating research into safe and effective treatments for patients, and seeks to understand the science underlying that process rather than any specific disease.

Whereas quality improvement at the local level remains important, more emphasis should be placed on translational science. Translational science is distinct from local quality improvement. Translational science seeks to implement practice change broadly throughout the health care system, using scientific and operational principles. It seeks to change all clinical practice. Quality improvement projects at the local level seek to optimize clinical practice within a local context. Quality improvement is most efficient and effective when based not only on high quality basic and clinical research, but on translational science as well. Generalizable knowledge about how research findings should be applied in clinical practice, resulting from translational research, provides a jumpstart for local quality improvement efforts.

The 21st Century Cures Act, proposed by Congress, is a more controversial approach to resolving the research to practice gap. The version of the 21st Century Cures Act recently passed by the House and referred to the Senate (Committee on Health, Education, Labor, and Pensions) has 3 important components: additional funding for the NIH, in part to support young investigators and precision medicine initiatives; acceleration of the FDA approval process for drugs and devices, including use of evidence from clinical experience rather than reliance on randomized clinical trials, and use of biomarkers and other surrogate markers as outcome measures; and increased after-market monitoring of drugs and devices. There are concerns that the acceleration of FDA approval may compromise safety. We have written before about the consequences of moving pharmaceutical agents into practice without the evidence of multiple randomized trials to verify effectiveness and safety; reducing the level of evidence
Clinicians should seek and use high quality evidence for their practice.

required for drug approval may speed more pharmaceuticals to market, but also may be associated with increased harm.

Conclusion
Critical care researchers and clinicians can contribute to narrowing the research to practice gap. Conducting larger, multisite studies rather than small single site studies would narrow the gap by enrolling required subjects more quickly and reducing the time required to complete research. Multisite studies also would provide more generalizable data, speeding translation to practice. New experimental designs such as adaptive trials, stepped wedge designs, and comparative effectiveness trials may increase the efficiency of clinical research. Further, critical care researchers can narrow the research to practice gap by presenting results in a way that provides actionable information to authors of guidelines and to clinicians. Clinicians should seek and use high quality evidence for their practice, including guidelines that synthesize the available evidence.

We value the crucial contribution the American Journal of Critical Care makes in disseminating high quality research that provides clear guidance for interdisciplinary clinical practice with high potential for improving outcomes for critically ill patients. Moving research into practice is a delicate balance of incorporating new findings quickly enough to maximally benefit patients, but not so quickly that we expose patients to unnecessary harm. Critical care practice has built on clinical and translational research since its inception, and we can lead the way in narrowing the research to practice gap.

The statements and opinions contained in this editorial are solely those of the coeditors in chief.

FINANCIAL DISCLOSURES
None reported.

eLetters
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REFERENCES

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Reminding Us That We Are “Tough and Competent”

Thank you for the inspiring (and for me, timely) editorial, “Tough and Competent.”1

I grew up in awe of space travel and desperately wanted to be a “nurse in space” on the space shuttle. So I read the editorial that recounted the history of NASA with enjoyment and fascination. In this current health care environment, there is a lack of leaders who will shine the light on “carelessness, incapacity, and neglect.” They are not inspiring us to be tough and competent, and to never compromise regarding our responsibilities. But this piece spoke to my head and heart when you referred to NASA’s operations and the parallels to critical care. A couple of weeks ago I had lost my inspiration when 5 health care–associated infections were sent to me tagged to the units in my division. This occurred after we had several months of 1 or 2 health care–associated infections. I was feeling defeated and worried that all of the work on reducing them was meaningless. The next day I decided to move forward and embrace the current state of events as a continued challenge. You are right about critical care professionals, we are tough and competent. We just need to be reminded of that.

Crystal Logsdon, ACNS-BC, MSN, CCNS, CCRN
Savannah, Georgia

FINANCIAL DISCLOSURES
None reported.

REFERENCES

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Accuracy of Electromagnetic Placement Devices

I wanted to respond to the article by Bryant et al, titled “Verifying Placement of Small-Bore Feeding Tubes: Electromagnetic Device Images Versus Abdominal Radiography.”2

Although the authors’ conclusions did not support eliminating radiographs to confirm correct tube placement following use of an electromagnetic tube placement device (EMPD), there are some major concerns with this study that need to be highlighted. First, training and competency are absolutely essential before a clinician uses any medical device. This holds true for any piece of equipment including the EMPD for feeding tube placement. The authors focused on the perceived inaccuracy of the EMPD. However, a focus and concern should be on inadequate nurse training and allowing clinicians without demonstrated competence to use a piece of equipment. With the EMPD, it is essential to include not only competency for tube placement, but also interpretation of the tracings.

In this study, nurse training was probably inadequate. The authors state “some degree of training” but “no documented evidence of standardized training or competency was found.” They also state there was “no provision for annual revalidations of clinical or written competencies.” Some nurses had zero supervised placements before placing feeding tubes. This is unacceptable. Numerous institutions use EMPD effectively and have safely eliminated routine radiograph confirmation for feeding tubes. These institutions have in-depth education, a minimum number of supervised placements, and competency demonstrations on placement and interpretation before clinicians can use the device.

Institutions with limited numbers of trained clinicians (tube teams) or with significant opportunities for feeding tube placements and more training have eliminated lung placements.2,3 In stark contrast to the Bryant et al study,1 I and my colleagues4,5 found clear accuracy with using EMPD placements and have safely eliminated radiographs. Also, Kaffarnik’s6 radiographic interpretations correlated 100% with Cortrak data even in patients with anatomic anomalies after surgery, and the Kaffarnik study ceased performing abdominal radiographs in most cases after the first 10 patients. In that study they used contrast with radiographs. The study I led4 found that after injecting contrast there was a 12% error in radiographic interpretation with small-bore feeding tube placement verification. The EMPD with cross-sectional view was found to be more accurate in predicting location of small-bore feeding tubes as opposed to the 2-dimensional view on a radiograph.7 In the Bryant et al study1 contrast was not used with radiographs.

The retrospective nature of this study did not allow review of critical factors in the use of EMPD and did not take into account possible procedural deviations. One key factor not addressed by this research is basic positioning and use of the EMPD. No data
were provided on the level on the depth cross-sectional or lateral views. This is critical information when determining placement in the small bowel. During a placement, when the tube traverses from the stomach to the small bowel, there will be an increase in depth as the small bowel is posterior to the stomach. The EMPD shows depth of placement in real time and if this was not observed, then the tube is most likely not in the small bowel. Previous studies have shown that radiographic interpretations can be misleading due to the limited anteroposterior view and the depth information on the EMPD contributes to more accurate interpretations.

Placement of the EMPD receiver is another critical element. This study was done retrospectively and accuracy of the receiver placement was not observed. If the receiver was placed too high on the patient, then tracings would appear lower than they actually were. Also, the receiver should be parallel to the patient’s spine, so if the receiver was angled up or down due to patient anatomy (ie, large abdomen or barrel chest), this alteration in position can also impact the placement.

The most concerning aspect of this study was the unrecognized lung placements. Inadvertent pulmonary placement is easily detected upon initial insertion using the EMPD, which is one of the key advantages of using a real-time visualization system. When the receiver is positioned properly with the front foot at the patient’s xiphoid process, pulmonary placement can be detected by a deviation off midline of the track into the upper quadrants. However, if the device was not started within the first 5 to 10 cm, or when passing the posterior pharynx, then it is possible that the final tracing could have shown the tube already in the lung and looked similar to a stomach placement. The critical aspect is observing the tracing upon insertion and watching the entire pathway of the tracing. If nurses were not trained adequately, this essential step may have been overlooked and could have resulted in the lung placements not being recognized.

Bryant et al1 concluded, “Based on results of this investigation, a process review and retraining of clinicians was initiated at the study institution.” This is a much needed, appropriate, positive outcome based on the results presented by the authors.

In summary, it is imperative that the results of this investigation not be taken out of context. These results are concerning, but we must consider that a lack of training in use and interpretation of the EMPD placements are the probable culprits, rather than malfunction or ineffectiveness of the device itself. As with any piece of medical equipment, when used incorrectly by untrained clinicians, patient injury can result.

If the device is used by competent, trained, skilled clinicians in the manner intended, then the EMPD has been shown in many previous research studies to be safe and accurate for feeding tube placements.

FINANCIAL DISCLOSURES
The author serves on the following speakers’ bureaus: Abbott Nutrition, Corpak, and Sage Products.

REFERENCES

Response:
We appreciate the thoughtful critique of our article and would like to respond to the key points raised by Dr Powers. First, we thoroughly agree that adequate training is needed for the electromagnetic placement device (EMPD) to be used successfully. We acknowledge that training on use of the device in our institution was likely inadequate. The question is, “What is adequate?” The successes described in studies cited by Powers were achieved by highly trained individuals. For example, prior to data collection, clinicians in the Koopmann et al study1 (4 nurse practitioners and 1 physician assistant) had 2 months experience with the device after being trained by a company representative. Perhaps the answer is for institutions wishing to use the EMPD to require similar degrees of training and experience for any clinician before he or she is allowed to use the device. However, the practicality and cost of this lengthy training program might be prohibitive to some institutions.

Second, we did not imply that the EMPD is a defective device. Instead, we described the inability of individuals in our institution to use the device effectively. According to case reports in the MAUDE (US Food and Drug Administration’s Manufacturer and User Facility Device Experience) database,2 other institutions are experiencing similar problems. We have no commercial interest (positive or negative) regarding the device. Our interest is in promoting patient safety.

Third, the writer indicates that “numerous institutions use the EMPD effectively and have

Response:

In summary, it is imperative that the results of this investigation not be taken out of context. These results are concerning, but we must consider that a lack of training in use and interpretation of the EMPD placements are the probable culprits, rather than malfunction or ineffectiveness of the device itself. As with any piece of medical equipment, when used incorrectly by untrained clinicians, patient injury can result.

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Jan Powers, RN, PhD, CCNS, CCRN, CRN, NE-BC
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FINANCIAL DISCLOSURES
The author serves on the following speakers’ bureaus: Abbott Nutrition, Corpak, and Sage Products.

REFERENCES

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Response:

In summary, it is imperative that the results of this investigation not be taken out of context. These results are concerning, but we must consider that a lack of training in use and interpretation of the EMPD placements are the probable culprits, rather than malfunction or ineffectiveness of the device itself. As with any piece of medical equipment, when used incorrectly by untrained clinicians, patient injury can result.

If the device is used by competent, trained, skilled clinicians in the manner intended, then the EMPD has been shown in many previous research studies to be safe and accurate for feeding tube placements.

Jan Powers, RN, PhD, CCNS, CCRN, CRN, NE-BC
Indianapolis, Indiana

FINANCIAL DISCLOSURES
The author serves on the following speakers’ bureaus: Abbott Nutrition, Corpak, and Sage Products.

REFERENCES

do: http://dx.doi.org/10.4037/ajcc2016815
safely eliminated radiograph confirmation for feeding tubes.” It would be helpful to know what kinds of training are used in these facilities. Again, this is important since there are clearly other institutions reporting far less success (as indicated in the MAUDE database).

Fourth, the reviewer commented on the disturbing problem of unrecognized lung placements in our retrospective study. We share this concern. That is precisely why we published our paper. The problem of inadvertent respiratory placements is not limited to our institution. Again, one only has to review case reports in the MAUDE database to recognize this fact.

In closing, we are hopeful that clinicians will consider the pros and cons of eliminating a confirmatory radiograph after EMPD-assisted tube insertions. Is the cost savings from such an action worth the potential risk to a patient?

VERA BRYANT, DNP, ARNP, ANCP-BC, CCRN, CMC, CNRN, SCRN
Miami, Florida

FINANCIAL DISCLOSURES
None reported.

REFERENCES

doi: http://dx.doi.org/10.4037/ajcc2016265
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Caring for critically ill patients undergoing mechanical ventilation in the intensive care unit (ICU) is an immense challenge for clinicians. Interventions to maintain physiological stability and life itself can cause a number of adverse side effects that significantly impact patients beyond the period of critical illness or injury. These ICU-acquired conditions include but are not limited to weakness, depression, and post-ICU syndrome. These conditions significantly impact the quality of life for our patients after they leave the ICU.

How best to manage the plethora of symptoms experienced by patients receiving mechanical ventilation without contributing to adverse ICU-acquired sequelae remains a daunting charge for clinicians and requires “out of the box” approaches to address this complex issue. Systematic, cutting-edge research is needed to challenge the “usual” way of managing patients in order to provide the best available evidence for practice integration that minimizes adverse ICU-acquired sequelae and improves outcomes for our most vulnerable patients. This article highlights a program of research focused on symptom management interventions for critically ill patients receiving mechanical ventilatory support, including the appropriate self-management of symptoms by mechanically ventilated patients. Development and testing of innovative, nontraditional interventions specifically tailored for ICU patients receiving mechanical ventilatory support will be presented.

Having patients listen to music will be highlighted as one nonpharmacological, adjunctive intervention to reduce mechanical ventilation-associated anxiety. Patient-controlled sedation will also be discussed as an alternative method to meet the highly individual patient needs for sedative therapy to promote comfort.

About the Author
Linda L. Chlan is associate dean for Nursing Research at the Mayo Clinic in Rochester, Minnesota. In addition, she is a fellow of the American Academy of Nursing.

Linda L. Chlan’s presentation will be published in its entirety in the July 2016 issue of AJCC.
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.

Spiritual-Care Guidance for Nurses

Person-centered holistic health care focuses on the mind, spirit, and body. However, advances in technology and science have led to a disconnection between care for the body and care for the soul. Canfield and colleagues interviewed 30 critical care nurses to identify their definition of spirituality, their level of comfort in providing spiritual care, and their need for education and guidance in this care. They found most nurses offered themselves to patients and families through personal presence, such as praying, listening, or touching. They did this within the following 3 patient-centered areas:

- End-of-life issues
- Resolutions surrounding guilt and hope
- Increased need for attention

In addition, 47% of the nurses defined spirituality as belief in a higher power and associated it with religion; 75% expressed a degree of comfort in providing spiritual support. The authors offer a definition of spirituality and recommend creation of resources to support nurses providing spiritual care at the bedside.

Nurse Underestimation of Pupil Size

Pupil assessments are an integral part of neurologic function evaluation and can alert the bedside team to important changes in patient status. Yet past studies have shown inconsistency and inaccuracy in these assessments by health care professionals. Kerr and colleagues conducted a 3-phase study using subjective measures to evaluate nurses’ accuracy in assessing pupil diameter and symmetry. They found that nurses tend to underestimate true pupil size when evaluating eye drawings, photographs, and adult patient pupils. More specifically, nurses made the following errors:

- Lower rates of accuracy as pupil diameter increased
- Inconsistency between their own measurements of duplicated images
- High rates of false positives and negatives in pupil reactivity

Given the critical information pupillary change provides, the researchers suggest use of standardized technology, such as an automated pupillometer, to increase accuracy in pupil measurement. This will assist practitioners in determining if early interventions are warranted.

Noninvasive Cardiac Output Measurement During Weaning

Mechanical ventilation (MV) is a necessary intervention for many patients in the intensive care unit (ICU). However, weaning from MV can reveal a comorbidity, such as cardiac disease, that can prevent successful weaning and potentially cause further sequelae. Tanios and colleagues evaluated the role of noninvasive cardiac output (CO) monitoring using an end-tidal carbon dioxide (ETCO₂) measurement device during a spontaneous breathing weaning trial. They found the following:

- Patients who failed MV weaning were unable to augment CO as early as 5 minutes into the spontaneous breathing trial, suggesting the presence of cardiac dysfunction as a contributing factor.
- Those who passed the spontaneous breathing trial had quicker weaning times, shorter total MV times, and shorter ICU length of stay.

The authors suggest noninvasive CO monitoring with ETCO₂ can be easily used with patients during MV weaning. Identifying those who fail from cardiac causes can enable bedside practitioners to implement targeted interventions.

Preventing Pressure Ulcers in High Risk Patients

Prevention of health care-associated pressure ulcers is a National Patient Safety Goal set by the Joint Commission and has great implications for hospital finances. Treatment of pressure ulcers is expensive and is no longer reimbursed by the Centers for Medicare and Medicaid Services if hospital acquired.

Byrne and colleagues evaluated the use of a prophylactic silicone adhesive hydrocellular sacral foam dressing in 3 intensive care units (ICUs). Their findings showed an overall decrease in ICU-acquired sacral pressure ulcers with the following unit-specific incidence rates:

- Surgical coronary care unit, 13 to 5.38/1000 patient-days
- Medical coronary care unit, 7.4 to 3.96/1000 patient-days
- Medical intensive care unit, 6.98 to 3.4/1000 patient-days

The authors recommend increased health-care team education along with implementation of the prophylactic dressing. They suggest future analysis of dressing use cost-effectiveness and study of prophylactic dressings on other body areas prone to pressure damage.
ENHANCING THE COMMUNICATION OF SUDDENLY SPEECHLESS CRITICAL CARE PATIENTS

By Carmen S. Rodriguez, PhD, ARNP-BC, AOCN, Meredith Rowe, RN, PhD, Loris Thomas, PhD, ARNP, ACNP/ANP-BC, Jonathan Shuster, PhD, Brent Koeppel, MS, and Paula Cairns, RN, MSN

Background Sudden speechlessness is common in critically ill patients who are intubated or have had surgery for head and neck cancer. Sudden inability to speak poses challenges for hospitalized patients because strategies to facilitate communication are often limited and unreliable.

Objective To determine the impact of a technology-based communication intervention on patients’ perception of communication difficulty, satisfaction with communication methods, and frustration with communication.

Methods A quasi-experimental, 4-cohort (control and intervention) repeated-measures design was used. Data were collected daily for up to 10 days. Patients in adult critical care units were followed up as they were transferred to other units within the institutions selected for the study. The impact of a technology-based communication system (intervention) was compared with usual care (control). Patients’ communication outcomes pertinent to communication with nursing staff that were evaluated included perception of communication ease, satisfaction with methods used for communication, and frustration with communication.

Results Compared with participants in the control group, participants in the intervention group reported lower mean frustration levels (-2.68; SE, 0.17; 95% CI, -3.02 to -2.34; P < .001) and higher mean satisfaction levels (0.59; SE, 0.16; 95% CI, 0.27 to 0.91; P < .001) with use of the communication intervention. Participants in the intervention group reported a consistent increase in perception of communication ease during the hospital stay.

Conclusions The results facilitated evaluation of a bedside technology-based communication intervention tailored to the needs of suddenly speechless critically ill patients. (American Journal of Critical Care. 2016; 25:e40-e47)

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STIMULATION OF CRITICALLY ILL PATIENTS: RELATIONSHIP TO SEDATION

By Mary Jo Grap, RN, PhD, ACNP, Cindy L. Munro, RN, PhD, ANP, Paul A. Wetzel, PhD, Jessica M. Ketchum, PhD, James S. Ketchum III, MS, William L. Anderson, PhD, Al M. Best, PhD, V. Anne Hamilton, RN, MS, Nyimas Y. Arief, BS, PhD, Ruth Burk, RN, PhD, Tenesha Bottoms, RN, BS, and Curtis N. Sessler, MD

Objectives To describe the number and type of stimulation events and the relationship of stimulation to sedation level in patients receiving mechanical ventilation.

Methods A 4-hour direct observation was conducted in 103 patients receiving mechanical ventilation. Stimulation events and sedation level before and after the stimulation were documented. Eight categories of stimulation events were developed in a previous pilot study of 36 patients receiving mechanical ventilation. Sedation was measured continuously by using a processed electroencephalographic score (patient state index [PSI]) and intermittently by using the Richmond Agitation-Sedation Scale.

Results Patients were mostly alert/mildly sedated (54.4%) at study enrollment. During the 349 hours of observation, 58.8% of the time included stimulation events. General auditory types of stimulation were most common (41.2% of observed time), followed by respiratory management and tactile family stimulation. For all events, auditory-talking, tactile-general, tactile-noxious, and tactile-highly noxious stimuli were associated with higher PSIs (all P < .001) after stimulation; other stimuli were not. Level of consciousness influenced response to stimuli, with almost all types of stimuli increasing PSI for patients more deeply sedated (PSI < 60) just before the stimuli. However, the effect of stimulation on PSI for more alert patients (PSI > 60) was small and variable.

Discussion Critically ill patients receiving mechanical ventilation are subjected to various forms of auditory and tactile stimulation frequently throughout the day. All types of stimuli increased arousal in patients who were more deeply sedated. The effect of stimulation in patients who were not deeply sedated was minimal and inconsistent. (American Journal of Critical Care. 2016;25:e48-e55)

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**Background** Backrest elevations less than 30° are recommended to reduce pressure ulcers, but positions greater than 30° are recommended during mechanical ventilation to reduce risk for ventilator-associated pneumonia. Interface pressure may vary with level of backrest elevation and anatomical location (eg, sacrum, heels).

**Objective** To describe backrest elevation and anatomical location and intensity of skin pressure across the body in patients receiving mechanical ventilation.

**Methods** In a longitudinal study, patients from 3 adult intensive care units in a single institution receiving mechanical ventilation were enrolled within 24 hours of intubation from February 2010 through May 2012. Backrest elevation (by inclinometer) and pressure (by a pressure-mapping system) were measured continuously for 72 hours. Mean tissue interface pressure was determined for 7 anatomical areas: left and right scapula, left and right trochanter, sacrum, and left and right heel.

**Results** Data on 133 patients were analyzed. For each 1° increase in backrest elevation, mean interface pressure decreased 0.09 to 0.42 mm Hg. For each unit increase in body mass index, mean trochanter pressure increased 0.22 to 0.24 mm Hg. Knee angle (lower extremity bent at the knee) and mobility were time-varying covariates in models of the relationship between backrest elevation and tissue interface pressure.

**Conclusions** Individual factors such as patient movement and body mass index may be important elements related to risk for pressure ulcers and ventilator-associated pneumonia, and a more nuanced approach in which positioning decisions are tailored to optimize outcomes for individual patients appears warranted. (American Journal of Critical Care. 2016;25:e56-e63)

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CRITICAL CARE NURSES’ PERCEIVED NEED FOR GUIDANCE IN ADDRESSING SPIRITUALITY IN CRITICALLY ILL PATIENTS

By Christina Canfield, RN, MSN, ACNS-BC, CCRN-E, Debi Taylor, RN, Kimberly Nagy, RN, Claire Strauser, RN, BSN, CCRN, NE-BC, Karen Vankerkhove, RN, BSN, Stephanie Wills, RN, BSN, Patricia Sawicki, RN, and Jeanne Sorrell, RN, PhD

Background The term spirituality is highly subjective. No common or universally accepted definition for the term exists. Without a clear definition, each nurse must reconcile his or her own beliefs within a framework mutually suitable for both nurse and patient.

Objectives To examine individual critical care nurses’ definition of spirituality, their comfort in providing spiritual care to patients, and their perceived need for education in providing this care.

Methods Individual interviews with 30 nurses who worked in a critical care unit at a large Midwestern teaching hospital.

Results Nurses generally feel comfortable providing spiritual care to critically ill patients but need further education about multicultural considerations. Nurses identified opportunities to address spiritual needs throughout a patient’s stay but noted that these needs are usually not addressed until the end of life.

Conclusions A working definition for spirituality in health care was developed: That part of person that gives meaning and purpose to the person’s life. Belief in a higher power that may inspire hope, seek resolution, and transcend physical and conscious constraints. (American Journal of Critical Care. 2016;25:206-211)
Although health care is grounded in the tradition of caring for the entire person, it can be argued that advances in technology and the emergence of new science have led to a disconnect between caring for the body and caring for the soul. To provide holistic care, nurses must be prepared to address all dimensions, including spiritual dimensions. Research has indicated that nurses often feel unprepared to meet the spiritual needs of their patients. A review of definitions in the literature revealed no common or universally accepted definition for the term spirituality. Without a clear definition, each nurse must reconcile his or her own beliefs within a framework mutually suitable for both nurse and patient.

### Literature Review

In 2001, the Institute of Medicine referred to health care in America as fragmented and impersonal. Since then, initiatives for an enhanced focus on patients’ satisfaction have created an increased demand to return to patient-centered or person-centered holistic care. Person-centered care focuses the locus of decision making back on the person receiving care. Watson describes the transpersonal caring relationship as one that explains how a nurse considers a person’s subjective meaning of the person’s health care situation. The nurse’s own caring consciousness lends connection and understanding of the other person’s perspective. The person and the nurse are both unique but find mutuality upon which to connect. The person and the nurse embark on a mutual search for meaning and wholeness and perhaps for the spiritual transcendence of suffering. Nurses may embrace holistic person-centered approaches to care to help patients achieve a balanced relationship between 3 interrelated entities: mind, spirit, and body.

Spiritual needs must be addressed in all patients, no matter what religion the patient practices. Although the concepts are often considered interchangeable both in practice and in literature, religion and spirituality are not synonymous. For some persons, spirituality is grounded in religion, whereas others see spirituality on a metaphysical or existential level. Narayanasamy and Owens found that confusion exists over the meaning of spirituality and therefore over the role of nurses in providing spiritual care.

Patients place high importance on consideration of spiritual matters; attention to emotional needs was identified as the third top priority in the 2010 Press Ganey hospital pulse report. Response to concerns or complaints and involvement in care were the top 2 priorities. A study of more than 4000 nurses revealed that 93% thought that attending to spiritual needs enhances the overall quality of nursing care. Kociszewski found that providing spiritual care has important meaning for nurses and enhances professional satisfaction. Spiritual care interventions by nurses promote a sense of well-being for the nurses and promote positive outcomes for patients.

As nurses face increasing responsibilities and workloads, the quality of spiritual care they are able to offer may be in jeopardy. Balboni et al concluded that spiritual training for nurses is critical to meet national end-of-life care guidelines. Yet, little is known about what type of training is needed to enhance competence in addressing the spiritual needs of patients. In research, the extent to which nurses are prepared to meet the spiritual needs of hospitalized patients, 60% to 79% of nurses indicated a need for more guidance and educational preparation. Lack of preparation and comfort may lead to hesitance in investigating patients’ spiritual needs.

### Aims

The purpose of this study was to learn more about critical care nurses’ self-described definition of spirituality in health care, to assess the nurses’ comfort in providing spiritual care, and to determine their perceived need for guidance in providing

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**About the Authors**

Christina Canfield is a clinical nurse specialist, eHospital, Cleveland Clinic, Cleveland, Ohio. Kimberly Nagy and Stephanie Wills are registered nurses, Claire Strauser is nurse manager, and Karen VanKerkhove and Patricia Sawicki are assistant nurse managers in the medical intensive care unit, Cleveland Clinic. Debi Taylor is a registered nurse, Sutter Tracy Community Hospital, Tracy, California. Jeanne Sorrell is a senior researcher emeritus, Cleveland Clinic.

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spiritual care to critically ill patients. Additionally, we sought to create a working definition of spirituality in health care to guide nurses within their organizations. The focus for the study evolved from discussions with nurses and spiritual care staff in the medical intensive care unit at Cleveland Clinic in Ohio. Informal discussions suggested that many critical care nurses did not feel confident in addressing the spiritual needs of their patients and wished for more education and guidance in how to meet these needs.

Methods

The holistic and multiperspective nature of spiritual care experiences are best addressed by using qualitative research approaches. A literature search did not reveal a common or universally accepted definition for spirituality, and only a few investigations focused on nurses addressing spiritual needs of critically ill patients. The phenomenological approach of von Manen was considered the best one for eliciting the “lived experience” of how nurses addressed spiritual needs while caring for critically ill patients.

After approval by the appropriate institutional review board, a purposeful cross-section of nurses who worked full-time, part-time, or as needed as direct caregivers in the 25-bed medical intensive care unit were recruited to participate in individual interviews. Nurses were recruited to provide representation of the overall nursing staff on the unit in terms of sex, ethnicity, and chronological age (Table 1).

The research team was composed of a nurse manager, 2 assistant nurse managers, a clinical nurse specialist, 3 bedside nurses, and a senior nurse scientist who served as research mentor. In order to prevent hierarchical differences and promote truth and disclosure, interviews were conducted by 2 nurses who worked as bedside caregivers on the unit. The research team acknowledged challenges inherent to using peers to conduct qualitative research.

The voluntary nature of participation in interviews was noted on the recruitment flyer along with assurance that all personal identifiers would be removed during transcription. The senior nurse scientist offered mentoring and behavioral coaching through role-playing to prepare the 2 nurses who conducted the peer interviews.

A total of 30 nurses participated in individual interviews conducted in a private conference room. The interviewers obtained written informed consent, which included consent to audio recording. A script of questions designed to elicit responses to meet the specific aims of the study was provided; however, interviewers were encouraged to ask additional open-ended questions to gain insight into the lived experiences of nurses in relation to the phenomenon of spirituality in the care of critically ill patients (Table 2). Interviews were transcribed by a member of the research team and then validated by the principal investigator.

Each member of the research team was provided with a deidentified copy of the transcribed interviews. An analysis of all responses to each interview question was conducted both independently and then collaboratively among members of the research team. Interpretive summaries were then developed. Data

Table 1

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Table 2

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<td>We are conducting a study about spirituality and would like to talk with nurses about their thoughts related to this topic. There is no clear definition of spirituality, particularly as it relates to nursing. Could you tell me about a time when you interacted with a patient who really needed some spiritual support or attention? (During dialogue: What motivated you?)</td>
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<tr>
<td>Please describe your personal definition of spirituality.</td>
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<td>How do you see the connection between religion and spirituality?</td>
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<td>(Do you feel like you have to be religious to be spiritual?)</td>
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<tr>
<td>Could you talk to me about your own comfort providing spiritual care to critically ill patients?</td>
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were further analyzed to determine themes and phenomena that aligned with the specific aims of the study.

Results

Researchers asked each participant to describe a time when the participant interacted with a patient who really needed some spiritual support or attention. Three patient-centered themes emerged: end-of-life issues, resolutions associated with guilt and hope, and increased need for attention. The overarching response was offering. Offering was defined as personal presence, praying, touching, holding a hand, or listening. Nurses who were unsure about how to respond to patients offered to contact pastoral care for support of the patient or the patient’s family. One nurse observed, “The doctors don’t stay there and talk to [the patient] for an extensive amount of time. They quickly just have the [end-of-life] discussion and leave. So, that’s what you are there for, . . . to provide additional support.” Regarding nurses’ presence, other nurses found that patients needing spiritual support might “require more attention than others. . . . They need a little more love than somebody else.”

Nurses made statements about a sense that something more than the technical aspect of their job was needed. When discussing a situation about a critical care patient, a nurse noted the following:

I feel like all of the end-of-life cases need some sort of spiritual being, . . . finally people come to that fact that they are mortal and that they are going to die and they feel like at some point then they need to make peace with a higher being of some religion or whatever even if they’re not, quote unquote spiritual people. So, they end up in, you know, they are searching, I guess, for some sort of an answer as to what’s gonna happen to either themselves or a loved one, um, when in fact, they do die.

When the interviewer asked, “So, as a nurse, how do you address that?” the nurse responded by saying the following:

Uh, open conversation I feel like is beneficial. To just to ask them how they are feeling, what’s going on, um, how they’re coping. I mean, we are lucky to have consults with spiritual priest or whatever you want to call them to come up and talk to families, but, I found that just being a presence, um, and giving them open opportunity to talk is the best way that I found to help them cope through a situation like that.

When discussing situations in which spiritual support was needed, several nurses spoke about experiences when their patients were seeking resolution at the end of life. Interfamily conflict over end-of-life decisions emerged as a common theme, with nurses sharing stories about patients who had made decisions to pursue comfort over aggressive treatment. One nurse shared an experience of a patient who felt he was ready to decline further aggressive intervention and move on to comfort care. His mother disagreed with his decision and caused him so much guilt and he was unable to take the steps he desired.

When nurses were asked to describe their personal definition of spirituality, 47% described a belief in a higher power, higher being, or God. Specifically, a nurse stated, “I believe that spirituality is just your relationship with a higher being; whatever it may be.” Another said, “I feel spirituality is your relationship with God, . . . being able to talk to God, however you pray or however you do it.”

Several nurses thought that spirituality was an extremely personal matter. One remarked, “I kind of think of it like pain. It’s like whatever somebody says it is.” Although some nurses did not make references to a higher being or God, many mentioned a higher power. One nurse stated, “I think it’s your connection to your purpose and to whatever you feel is driving you for existence.” Another nurse stated:

I think sometimes religious people are more spiritual. It seems like they just are more in touch with things but, I’m not religious, . . . when things are going bad I look to somebody to help me. Whether it be, like, God or, you know, my deceased relatives or something. Just somebody, like, give me strength to get me through something.

Interestingly, when speaking about the ambiguity of spirituality, a nurse stated, “I think everyone’s definition would be completely different . . . I don’t know. Like a background that no one can really explain.”

Nurses were then asked the following question, How do you see the connection between religion and spirituality or do you feel like you have to be religious to be spiritual? All stated that they did not feel a person had to be religious to be spiritual; however, the majority of the nurses then referenced religion as a means to express spirituality. When discussing religion as it relates to spirituality, a nurse noted, “You know, it’s more just a connection with people, and . . . making their experience better.”
Another nurse commented, “Religion . . . is more of a belief. Whereas, spirituality . . . is more of a feeling.” Still another nurse stated, “I feel like religion is more of a set, a creed and structure and also a feeling of belonging to a people of the similar belief system and spirituality is your own internal connection.”

When nurses were asked about their comfort level with providing spiritual care to critically ill patients, 75% expressed some degree of comfort. Nurses are ready to offer direct spiritual support if they sense it is needed but hesitate to initiate such support for fear that the offer will be interpreted as proselytizing and offensive to the patient or the patient’s family. One nurse shared the following: “I’m not super comfortable just because everybody has their own beliefs and their own definition of spirituality and . . . it can encompass such a broad range of beliefs that it’s hard to know what to say, or how to relate to the patient. . . . I don’t want to say anything to offend anybody or make them feel uncomfortable. Not knowing a patient’s beliefs leads to discomfort. Nurses relied heavily on sensing cues from the patient or the patient’s family and appeared to be most comfortable with offering spiritual care when a patient or the patient’s family asked for such care. If nurses did not sense the need for or the patient did not request spiritual care, they were hesitant to offer anything directly. Some nurses described providing spiritual care as being supportive through offering their presence: holding a hand, listening, offering a hug. Nurses viewed the heavy demands of providing physical care as a barrier to taking time to provide spiritual care.

When asked what kind of education would be beneficial in improving their comfort with providing spiritual care to patients, some nurses mentioned formal classes in different religions, cultures, or spiritual values. Others suggested a reference guide on the unit that they could consult as needed, another example of the perception that religion is a means to expressing spirituality. Other nurses thought that formal class work might not be helpful because they would forget the details if they did not have a patient of a particular religion or culture until a much later date. Nurses described a need for learning how to start a conversation about spirituality, as well as knowing what the “rules” were so far as what was acceptable to initiate with the patients.

Of note, a few nurses were averse to spiritual education. One said, “Even if . . . I was educated on it, I still . . . wouldn’t . . . I would just rather not, not be involved with it. . . . I’d feel more comfortable that way.” Interestingly, this same nurse remarked, “I’m just a caring person. I’ll care, but, I don’t really like getting involved. . . . I’m not a religious person.” This reply illustrates not only the need for education but also the need for defining spirituality as the term pertains to health care. Most likely, defining spirituality would be the first step in developing a framework for confident practice among nurses who are struggling to recognize their own spiritual competence. Nurses who are confident providing spiritual care recognize the need for education and support from more experienced mentors. A nurse who had practiced for 24 years stated, “I just think the nurses need to know it’s OK . . . if the family is praying, you can stand there quietly and offer, show your support, you know, you don’t have . . . to be afraid to let them know that . . . you do believe in something and . . . you’re not just about the technical stuff.”

Discussion

In this qualitative study, we explored critical care nurses’ perceived needs in addressing spirituality in patients. The nurses in our sample identified the concept of spirituality with belief in a higher power. Although religion is not necessarily tied to spirituality, nurses noted that religion is often a means to express one’s spirituality. Nurses respond to a patient’s needs by offering themselves to provide direct support or by reaching out to others when they think they are not equipped to address the patient’s needs. Our findings support existing evidence that nurses do not feel completely prepared or comfortable in attending to the spiritual aspect of patient care.2,11 The nurses in our study perceived a need for further education or readily available resources to assist them in providing culturally competent spiritual care.

Limitations of this study include the setting and demographics. The research was conducted in a single site at a large teaching hospital among nurses who provided care to patients with pulmonary, renal, or liver disease. Replicating this study in a surgical, cardiac, or neurological intensive care unit might not produce the same results.

Nurses were recruited from a purposeful cross-section of direct caregivers on the designated unit. Variability in ethnic background, sex, and nursing experience among the sample was limited. Therefore, our results may not be generalizable to the overall population of critical care nurses.
Conclusion

Developing a definition of spirituality pertinent to health care is imperative to empower nurses who seek to give whole-person care to their patients. Governing agencies mandate spiritual assessment and interventions by health care providers; however, no accompanying framework to guide this practice is available. After interviews with the 30 intensive care nurses in our study, the following definition of spirituality was developed: That part of a person that gives meaning and purpose to the person’s life. Belief in a higher power that may inspire hope, seek resolution, and transcend physical and conscious constraints.

Our findings from this phenomenological study provide a framework for creation of resources to support critical care nurses as they deliver care at the bedside. Additionally, the results provide the foundation for further research related to strategies for addressing spiritual needs of critically ill patients.

ACKNOWLEDGMENTS
The research team gratefully acknowledges Jeanne Sorrell, RN, PhD. Without Dr. Sorrell’s expert guidance, this project would not have been possible. Additionally, the research team extends gratitude to the nurses working in the medical intensive care unit (G60 and G61) at Cleveland Clinic for their willingness to participate in this project.

FINANCIAL DISCLOSURES
None reported.

eLetters
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REFERENCES

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Addressing spirituality is part of the holistic care that critical care nurses seek to provide, and it is an area that sometimes makes us feel uncertain or uncomfortable. We can measure the growth of our skills in performing psychomotor and cognitive tasks—the time it takes to start a new intravenous line or the accuracy of a blood gas analysis—but tasks related to spiritual care are less tangible. How and when should we offer spiritual support? How do we know if we are getting it right?

We meet our patients and their families when they are vulnerable and likely to seek strength from a spiritual connection with a nurse. The creation of a protocol or a clinical practice guideline for care that must be individualized to a specific set of needs and beliefs is challenging. However, attending to spiritual needs not only results in higher patient and family satisfaction but also eases our own pain as we witness their suffering. All nurses have faced moments of, “I just don’t know what to say.” An important point in Canfield and colleagues’ findings is that sometimes spiritual care involves saying nothing, just listening or reaching to hold a hand.

Here’s what you can do:

- Notice when patients or families are seeking spiritual care and avoid redirecting attention to physical aspects of the patient’s illness.
- Prioritize assessment of the family’s and patient’s ability to find meaning even when, and maybe especially when, the patient’s physical state demands your highest skill and attention.
- Take time to think about your own spirituality: How do you find meaning and purpose beyond physical sense or consciousness?
- Invite a member of the pastoral care department to a staff meeting to discuss spiritual care.

Other helpful resources:
The End-of-Life Nursing Education Consortium includes resources for spiritual care, http://www.aacnnche.edu/elnec/elnec-web-resources.

Based on material from and published as a supplement to the article by Canfield and colleagues, “Critical Care Nurses’ Perceived Need for Guidance in Addressing Spirituality in Critically Ill Patients” (American Journal of Critical Care. 2016;25:206-211).
Background  Early detection of pupillary changes in patients with head injuries can alert the care team to increasing intracranial pressure. Previous research has shown inconsistencies in pupil measurement that are most likely due to the subjective nature of measuring pupils without the assistance of technology.

Objectives  To evaluate nurses’ abilities to assess pupil diameter accurately and detect unequal pupils.

Methods  In a 3-part study, the accuracy of critical care and neurosurgical nurses’ assessments of pupils was determined. The study included assessment of drawings of eyes with an iris and pupil, examination of photographs of human eyes, and bedside examination of patients with a head injury.

Results  Subjective assessments of pupil diameter and symmetry were not accurate. Across all phases of the study, pupil diameters were underestimated and the rate of error increased as pupil size increased. Nurses also failed to detect anisocoria and misidentified pupil reactivity. In addition, nearly all nurses relied on subjective estimation, even when tools were available.

Conclusions  Critical care and neurosurgical nurses underestimated pupil size, were unable to detect anisocoria, and incorrectly assessed pupil reactivity. Standardized use of pupil assessment tools such as a pupillometer is necessary to increase accuracy and consistency in pupil measurement and to potentially contribute to earlier detection of subtle changes in pupils. If pupillary changes are identified early, diagnostic and treatment intervention can be delivered in a more timely and effective manner. (American Journal of Critical Care. 2016;25:213-219)
Regular assessments of pupils are important for monitoring and assessing neurological function of patients with head injuries. Changes in pupil size may signal neurological deterioration and a need for a change in clinical management. Serial assessments are vital for early identification of subtle changes in patients’ neurological status. Prior research, however, has documented that health care professionals are inconsistent and inaccurate in measuring pupil diameter. Although protocols specify the conditions under which pupillary examinations should occur (eg, room lighting, angle of light shone in the eye), health care professionals are rarely compliant with these recommendations. This lack of compliance is problematic if inaccuracies and inconsistencies prevent detection of pupillary change and delay clinical intervention.

Clinical evaluation of pupils focuses on 4 characteristics: size or diameter, reactivity to light, shape, and presence of anisocoria. Of these, changes in pupil diameter or development of anisocoria may be most important. Pupil size is measured in millimeters, and the mean pupil diameter is from 2 to 6 mm. Although both pupils are typically the same diameter, a discrepancy of less than 1.0 mm is considered to be within the normal range. In a trauma population, unequal pupils are one indicator of traumatic brain injury; thus detection of anisocoria may be clinically relevant.

Technology exists to diminish measurement discrepancies. A pupillometer is an infrared system that analyzes pupil dynamics over a brief time period, during which time the angle and intensity of light is controlled and multiple assessments are recorded. The instrument has higher reliability and greater precision than subjective estimates and can detect changes in pupil reactivity hours before changes in intracranial pressure are noted. Few studies have compared subjective measurement by nursing staff with objective measurement by using a pupillometer. The purpose of this 3-phase study was to evaluate nurses’ accuracy in assessing pupil diameter and symmetry. Two phases assessed accuracy of estimation with drawings and pictures, and the final phase compared standard bedside assessment with assessments with a pupillometer. The research objectives were 3-fold: determine the accuracy of current practice, specify the thresholds at which the quality of subjective pupil measurement degrades, and examine nurses’ ability to detect sluggish and unequal pupils.

Methods

The following study has 3 subcomponents, which we refer to as phase 1, phase 2, and phase 3. All phases were approved by the institutional review board at Iowa Methodist Medical Center, part of the UnityPoint Health System, in Des Moines, Iowa.

Procedure: Phase 1 and Phase 2

Critical care and neurosurgical nurses at Iowa Methodist Medical Center, a level 1 trauma facility in Des Moines, were asked to participate in a study assessing variability in pupil estimation. Nurses were recruited until a sample size of 30 was reached. They were asked to participate in phase 1 and phase 2, with 2 weeks between phases. All data were collected in the spring of 2012. Nurses were given study forms and told that filling out the forms indicated their consent. It took about 5 or 10 minutes to go through the study forms. Demographic variables were collected at each phase, including sex (male/female), age (20-35 years old, 36-50 years old, or ≥51 years old), years of experience in nursing, and whether or not the nurse wore corrective lenses (yes/no).

For the first phase, each nurse was given a packet of 12 randomly ordered black and white drawings of an eye with an iris and pupil. The size of the pupil ranged from 1 mm to 10 mm (Figure 1). Two of 10 drawings (20%) in each packet were duplicated to
check for intrarater agreement. Each sheet of paper contained a single eye figure. In the second phase, nurses were presented with 24 color pictures of eyes; each picture included both the right and left eyes (Figure 2). Four of 20 photos in each packet (20%) were duplicated to check for intrarater agreement. Half of the photos were altered in photo editing software to expand the size of 1 pupil to create anisocoria. All pupils were between 2.5 mm and 8 mm in diameter, and each packet included 5 pictures with unequal pupils that differed by 0.5 to 1.0 mm. All nurses who participated in phase 2 also participated in phase 1.

**Procedure: Phase 3**

In the third phase, bedside nurse assessments were compared with measurements made with the pupillometer. Data were collected prospectively from February 2013 through February 2014 as patients were admitted to the intensive care unit or a neurosurgical inpatient floor with qualified diagnoses. If a patient had repeat hospitalizations during the study period, only the first encounter was included in analyses. The study phase had approval from the institutional review board, but the requirement of informed consent was waived because the risk to patients was no more than minimal.

Patients were identified in the electronic medical record (EMR) on a daily basis, and the study team was alerted when a patient met criteria. Inclusion criteria were age 18 years or older; diagnosis of subdural, subarachnoid, epidural, or intracerebral hemorrhage, or other head injury; and at least 1 reactive pupil. Patients were excluded from the study if they had ocular injury or malformation in both eyes or if they were discharged from the hospital before the study team could complete the initial assessment. Each eye was considered a measurement, so in most cases, a single visit to the bedside resulted in 2 measurements. Up to 20 measurements were collected from each patient.

Bedside examinations using the pupillometer were conducted by study coordinators. Initial training was conducted via a web conference with the manufacturer of the pupillometer. The instrument used was the NPi-100 (NeuroOptics Inc), which is a noninvasive, hand-held device that stored all assessments on the instrument through the duration of the study. This study was investigator-initiated, and no payments or in-kind donations were received from the manufacturer.

After a patient was identified, the study coordinator approached the bedside nurse to inquire about a convenient time to conduct a pupil check. At the arranged time, the bedside nurse conducted an assessment using the normal standards of practice and provided the readings aloud, which were recorded by the study coordinator. If the bedside nurse gave a range, the study coordinator recorded the range but later calculated the midpoint. (For example, “between 4 and 5” was calculated as 4.5 mm.) The study coordinator then followed immediately with the pupillometer assessment and recorded the measurements. The study coordinator conducted the pupillometer assessment in the same lighting conditions as the bedside nurse. The entire assessment took less than 5 minutes; measurements were taken at intervals no less than 2 hours apart and at the convenience of the bedside nurse.

Demographic information was collected from the EMR after assessments were completed, including the patient’s age, sex, diagnosis, mechanism of injury, admission date and time, and initial score on the Glasgow Coma Scale (GCS). If the diagnosis was from a traumatic injury, Injury Severity Score and injury mechanism were abstracted from the trauma registry. For each measurement, the study coordinator recorded the date and time of the assessment, the location in the hospital (intensive care unit or general inpatient floor), whether or not the bedside nurse used a pupil card or dimmed the lights, the pupil diameter (in millimeters), and whether the pupil reaction was noted to be absent, sluggish, or brisk.

The pupillometer provided additional data, including minimum and maximum diameter readings and a neurological pupil index (NPI). The NPI is an algorithm for describing a pupil’s reactivity to light: a reading between 3 and 5 is considered brisk (normal), readings below 3 are considered sluggish, and the pupil is considered nonreactive as NPI.
Accuracy of nurses’ assessment decreased as pupil diameter increased.

Table 1
Measurements for phases 1, 2, and 3: comparing nurse assessment to objective measurement

<table>
<thead>
<tr>
<th>Objective measurement, mm</th>
<th>Nurses’ measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Phase 1: Drawings (n = 234)</td>
<td></td>
</tr>
<tr>
<td>Nurse, mm</td>
<td>1.1</td>
</tr>
<tr>
<td>Difference, mm</td>
<td>-0.2</td>
</tr>
<tr>
<td>Number of assessments</td>
<td>28</td>
</tr>
<tr>
<td>Phase 2: Photographs (n = 540)</td>
<td></td>
</tr>
<tr>
<td>Nurse, mm</td>
<td></td>
</tr>
<tr>
<td>Difference, mm</td>
<td></td>
</tr>
<tr>
<td>Number of assessments</td>
<td></td>
</tr>
<tr>
<td>Phase 3: Pupillometer (n = 489)</td>
<td></td>
</tr>
<tr>
<td>Nurse, mm</td>
<td>1.9</td>
</tr>
<tr>
<td>Difference, mm</td>
<td>0.9</td>
</tr>
<tr>
<td>Number of assessments</td>
<td>8</td>
</tr>
</tbody>
</table>

*Objective measurement indicates the true measurement, as assessed with a ruler in phases 1 and 2 and with a pupillometer in phase 3. For each objective measurement, the first number indicates the beginning of the range. For example, 1.0 indicates the measurement was 1.0 or greater and less than 1.5. Dashes indicate that no drawing, photograph, or patient was available at that measurement increment.

Statistical Methods
All analyses were conducted in IBM SPSS Basic Statistics for Windows, version 20.0 (IBM Corp, 2011). Descriptive statistics are presented as means (standard deviations) for continuous variables and as counts (percentages) for categorical variables. Correlations were assessed as Pearson correlation coefficients with a 95% confidence interval.

Results
Phase 1
In phase 1, 30 nurses assessed pupil size by using the method they most typically use for patient care. Two nurses used a pupil card and the other 28 nurses (93%) made subjective estimates. The nurses had a mean of 13.4 years of experience in nursing and 9.7 years of experience in critical care or neurosurgical nursing.

The accuracy of nurses’ measurements decreased as pupil diameter increased (Table 1). When the pupil was 1 mm in diameter, the nurses underestimated the pupil size by a mean of 1.2 mm. Nurses were internally inconsistent, with only 49% of pupils measured identically in the duplicated drawings. Accuracy was not correlated with the nurses’ use of corrective lenses, sex, age, or years of experience in a critical care or neurosurgical setting.

To determine the threshold at which accuracy was impaired, the accuracy of measurement was compared by using a cutoff of 4 mm. When the actual measurement in the drawing was 4.0 mm or less, 100% of nurses gave a measurement in that range. However, when the actual measurement was 5.0 mm or greater, only 54% of nurses indicated a measurement greater than 5.0 mm.

Phase 2
The second phase included 27 nurses. Two nurses used a pupil card and the other 25 nurses (93%) made subjective estimates. The accuracy of the nurses’ measurements again decreased as pupil diameter increased (Table 1). When the pupil was 2.5 mm in diameter, the diameter was underestimated by a mean of 0.4 mm, but when the pupil was 8.0 mm in diameter, the size was underestimated by a mean of 1.4 mm. When assessing the pictures with unequal pupils, one-third of the photographs were correctly identified as unequal.

Intrarater agreement was assessed. Overall, nurses measured the duplicated photographs consistently only 54.8% of the time; the consistency level varied widely as 2 nurses were consistent with their own measurements 0% of the time and 2 nurses were consistent 100% of the time. However, when the nurses saw the exact same photographs at 2 different time points, they measured the pupils consistently and correctly only 11.7% of the time. The rate of internal agreement did not correlate
with any of the demographic variables in the study, and the rate of internal consistency did not correlate with the overall rates of accuracy.

Accuracy was once again compared with the cutoff of 4.0 mm. When the actual measurement was 4.0 mm or less, 98.4% of nurses reported a diameter of 4.0 mm or less; when the actual measurement was 4.5 mm or greater, only 37% reported a diameter of 4.5 mm or greater.

Phase 3

In the third phase, 489 assessments were conducted on 93 patients. The mean age of patients in the study was 61.0 (SD, 19.1) years and 60% of patients were male (Table 2). The most common diagnoses were subdural hemorrhages and subarachnoid hemorrhages, and mean Injury Severity Score for patients with traumatic injuries was 25 (SD, 9.8). Sixty-one percent of the assessments were conducted in the intensive care unit (Table 3). None of the assessments were conducted with the assistance of a pupil card, but room lights were dimmed in more than two-thirds of the assessments.

A mean pupil size of 2.92 (SD, 0.97) mm was obtained from the measurements recorded by the nurse, and the pupillometer recorded a mean pupil size of 2.85 (SD, 0.90) mm. The differences between nurse and pupillometer assessments were very close when the actual diameter was less than 4.0 mm (Table 1). However, when the actual diameter exceeded 4.0 mm, nurses did not identify unequal pupils correctly, with accurate identification in only 33% of the pictures and 58% of the patients.

Table 2
Demographic characteristics of the 93 patients in phase 3

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Valuea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>56 (60)</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>61.0 (19.1)</td>
</tr>
<tr>
<td>Initial score on Glasgow Coma Scale, mean (SD)</td>
<td>13 (4.31)</td>
</tr>
<tr>
<td>History of diabetes</td>
<td>19 (20)</td>
</tr>
<tr>
<td>History of cataracts</td>
<td>5 (5)</td>
</tr>
<tr>
<td>History of glaucoma</td>
<td>5 (5)</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
</tr>
<tr>
<td>Subdural hemorrhage</td>
<td>39 (42)</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>23 (25)</td>
</tr>
<tr>
<td>Skull fracture</td>
<td>22 (24)</td>
</tr>
<tr>
<td>Other head injury</td>
<td>18 (19)</td>
</tr>
<tr>
<td>Injury Severity Score, mean (SD)</td>
<td>25 (9.8)</td>
</tr>
<tr>
<td>Mechanism</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>46 (49)</td>
</tr>
<tr>
<td>Assault</td>
<td>6 (6)</td>
</tr>
<tr>
<td>Intracranial pressure monitoring</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Died</td>
<td>4 (4)</td>
</tr>
</tbody>
</table>

a Values are number (percentage) of patients unless otherwise noted in first column.

Table 3
Data on 489 assessments performed in phase 3

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Valuea</th>
</tr>
</thead>
<tbody>
<tr>
<td>In intensive care unit</td>
<td>298 (60.9)</td>
</tr>
<tr>
<td>With lights dimmed</td>
<td>339 (69.3)</td>
</tr>
<tr>
<td>Pupil card used</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Pupil size, mean (SD), mm</td>
<td></td>
</tr>
<tr>
<td>Nurse</td>
<td>2.92 (0.97)</td>
</tr>
<tr>
<td>Pupillometer</td>
<td>2.85 (0.90)</td>
</tr>
<tr>
<td>Pupil reactivity normal</td>
<td></td>
</tr>
<tr>
<td>Nurse</td>
<td>375 (76.7)</td>
</tr>
<tr>
<td>Pupillometer</td>
<td>448 (91.6)</td>
</tr>
</tbody>
</table>

a Values are number (percentage) of assessments unless otherwise noted in first column.

Discussion

Study results indicate that accurate assessment of pupil diameter and reactivity is difficult when measured subjectively. When evaluating drawings, photographs, and patients, nurses had lower rates of accuracy as pupil diameter increased. Specifically, accuracy declined when the objective measurement exceeded 4.0 mm. In addition, nurses did not identify unequal pupils correctly, with accurate identification in only 33% of the pictures and 58% of the patients. Results suggest that subjective assessment of
If pupillary changes are noted early, treatment can be timely and effective.

pupil diameter and anisocoria is fraught with problems and could lead to delays or failures in detecting important signs of neurologic deterioration.

The study was designed in 3 phases in order to progress from the most basic assessment (simple black-and-white drawings) to the more complex assessments on real patients. Findings reveal that manual pupil assessment is susceptible to inaccuracy at even the most basic level (phase 1). In other words, manual assessment of a static, simple drawing was prone to error; assessment is inherently more complicated when evaluating a real patient.

Results are consistent with prior research but extend knowledge on this topic in several important ways. First, in all phases the trend was toward underestimates of the true diameters, and the rate of error increased as pupil size increased (Figure 3). Previous work is discrepant about whether the accuracy of assessment varies as pupil size increases. For example, Hults and colleagues reported that visual assessment was more difficult as pupil diameter decreased, but Meeker et al and Taylor et al found more error as pupil diameter increased. Arguably, in the neurologic critical care setting, important evaluation occurs when pupils are large and enlarging as pupil dilation may indicate cerebral ischemia or herniation. Findings of this study indicate that pupils will be underestimated by as much as 1.5 mm, which could affect clinical decisions. In addition, we quantify the threshold where accuracy deteriorates (between 4 and 4.5 mm). Other studies have specified an error rate but failed to note the diameters where subjective estimates degrade significantly. This threshold is important because it could specify the diameters at which more frequent and accurate measurement is warranted.

Second, we show that nurses were inconsistent with their own measurements of duplicated images. Previous studies have looked at interrater reliability, but no study of which we are aware has specified such low rates of intrarater reliability. This finding is crucial because 1 nurse may conduct all the serial assessments on a patient during a shift, and inaccurate measurements could result in failure to detect pupillary changes.

Third, we found that subjective estimates were inadequate in detecting anisocoria that could be imperative to early detection of neurological impairment, which confirms the findings of other studies. Nurses also had high rates of false-positives and false-negatives when assessing pupil reactivity. More than 20% of sluggish pupils were misjudged as normal in reactivity, and 17% of normal pupils were misjudged by the nurses as sluggish. This finding reaffirms the difficulty in accurately assessing pupil reactivity and underscores the need for more reliable means of assessment.

Limitations

This study has several limitations. First, the sample size of nurses in phase 1 and phase 2 was fairly small and relatively homogeneous, although there is no reason to believe that nurse demographics affect study outcomes. Second, in the first 2 phases, measurements were taken from 2-dimensional images on paper and not from real patients, which may limit the validity of the results. Images from drawings and photographs cannot show pupil reactivity, which is an important aspect of a pupil examination. Third, published reports have established that dark brown irises may be more difficult to assess, and we did not control for the color of the iris in our analyses. Prior researchers have found no diminished accuracy with the pupillometer based on the color of the iris, but more work is warranted to examine the relationship between iris color and pupil reactivity in manual assessment. Fourth, only 2 nurses used a pupil card in the first 2 phases, and no nurse used a measurement tool in phase 3. This finding is consistent with results of other studies, yet it should be noted that accuracy might increase if nurses were required to consistently use a tool for pupil measurement. Finally, published reports state that pupils become smaller as people age. The mean age of patients in phase 3 was 61.0 (SD, 19.06) years, which potentially biases the results and limits the generalizability of our findings.

![Figure 3 Scatterplot of measurements made with the pupillometer and by nurses.](image-url)
Summary

If pupillary changes are identified early, diagnostic and treatment intervention can be delivered in a timely and effective manner. Study results demonstrate that nurses underestimate pupil diameter when using subjective methods and are inconsistent with their own readings. Further work is warranted to determine if accuracy improves through the use of a pupillometer, leading to earlier detection of pupillary changes and improved outcomes for patients.

ACKNOWLEDGMENTS
We extend our gratitude to Garret Lechtenberg, Sheryl Sahr, Kit VanderPloeg, and all the nurses who participated in the study.

FINANCIAL DISCLOSURES
None reported.

eLetters
Now that you’ve read the article, create or contribute to an online discussion on this topic. Visit www.ajcconline.org and click “Submit a response” in either the full-text or PDF view of the 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.
Evidence-Based Review and Discussion Points

By Ronald L. Hickman, RN, PhD, ACNP-BC

Evidence-Based Review (EBR) is the journal club feature in the American Journal of Critical Care. In a journal club, attendees review and critique published research articles: an important first step toward integrating evidence-based practice into patient care. General and specific questions such as those outlined in the “Discussion Points” box aid journal club participants in probing the quality of the research study, the appropriateness of the study design and methods, the validity of the conclusions, and the implications of the article for clinical practice. When critically appraising this issue’s EBR article, found on pp 213-219, consider the questions and discussion points outlined in the “Discussion Points” box.

The examination of a patient’s pupils is an essential practice to detect neurological deterioration and the need for changes in a patient’s plan of care. A pupil examination consists of the inspection of pupils to assess size, shape, reactivity to light, and symmetry. Previous research has confirmed that serial pupil examinations are a crucial component in evaluating neurological status among critically ill patients.

However, inconsistencies and inaccuracies in pupil assessments by critical care nurses can contribute to failure to recognize clinically significant changes in pupil size that are linked to neurological deterioration. This can lead to delays in time-sensitive interventions needed to minimize the progression of neurological injury.

In an effort to describe the inconsistencies among critical care nurses performing pupil examinations, the authors conducted a 3-phase descriptive study to determine the accuracy of critical care and neurosurgical nurses’ pupil examinations.

In phase 1, the study investigators recruited 30 critical care nurses to evaluate 12 black and white drawings of an eye with an iris and pupil. Participants in this phase were instructed to inspect each drawing and estimate the pupil size.

Phase 2 consisted of the same 30 participants. However, in this phase, participants were presented with 24 color photographs of eyes and were asked to inspect the pupils and describe the size and symmetry of the pupils.

In phase 3, a total of 489 pupil assessments were conducted on 93 critically ill adult patients with a diagnosis of intracranial hemorrhage or traumatic head injury. Pupil assessments were obtained from the critical care nurses assigned to the patient and a pupillometer measurement captured by the research staff.

Based on the data generated from this descriptive study, the study investigators concluded that critical care nurses’ subjective assessments of pupils are consistently inaccurate. Across all phases of the study, critical care nurses regularly underestimated
the pupil diameter, inaccurately assessed pupil symmetry, and were unable to detect anisocoria and impaired pupil reactivity. The authors conclude that accurate assessment of pupil diameter and reactivity is difficult when critical care nurses only employ subjective assessment methods, and recommend the use of a standardized assessment tool, such as the pupillometer, to enhance accuracy of the pupil examinations.

Information From the Authors
Sarah Spilman, MA, a coauthor on this EBR article, provides additional information about the study. She says that the goal was to contribute to the literature on conduct of pupil assessments among critically ill patients with an acute neurological injury.

According to Spilman, the project was the culmination of efforts of expertise across several specialties: neurosurgery, nursing, and psychology. She adds, “The research was initiated by Robert Kerr, MD, PhD, a neurosurgeon at our facility, and he formed a study team with clinical and methodological expertise. The 3-phase study design was conceptualized to ensure the results of each phase would be able to stand on their own merit.”

Reflectively, Spilman notes that it is important to balance between clinical and research expertise when developing a study. “We have found that achieving a balance in the team’s expertise is essential to the design and execution of a project,” says Spilman. The authors concluded that the success of this project was due to the collaborative contributions between experienced clinicians and nonclinical scientists, which provided the requisite expertise to examine the ability of critical care nurses to accurately assess pupils using standard practices.

Implications for Practice
Spilman encourages readers of the American Journal of Critical Care to adopt standardized pupil assessment tools to promote the early detection of pupillary changes. “Pupil assessment is subjective, and even the most experienced and well-trained nurses were found to inaccurately assess pupils,” adds Spilman.

This study established that objective assessments are crucial to providing the best care to a critically ill patient with a neurological injury. The authors advise, “All intensive care units should be equipped with at least one pupillometer, which can diminish the subjectivity in the bedside pupil assessment, enhance the consistency across staff and facilitate earlier detection of subtle changes in the patient’s neurological status.” They believe use of a pupillometer will make it easier for critical care professionals to acquire reliable data and make sound clinical decisions.

Discussion Points

A. Description of the Study
- What is the purpose of the study?
- What are the characteristics typically assessed when inspecting the pupil?

B. Literature Evaluation
- What is the evidence in support of serial pupil assessments among the critically ill?
- What is the major methodological challenge concerning pupil assessments?

C. Sample
- Who was eligible to participate in this study?
- Why do you suspect the same nurses were used in phases 1 and 2?

D. Methods and Design
- Given the purpose of this study, why did the authors carry out a 3-phase study?
- Explain how the authors determined whether the critical care nurses’ assessments were accurate across the phases of the study.

E. Results
- What were the major findings of this research?
- How can you use the findings of this research to improve the quality of your nursing care?
Background
Health care legislation can be difficult to understand and apply in critical situations where patients may not be physically capable of autonomous control of confidential health information. Nurses are often the first to encounter confidential information about patients.

Objectives
To explore critical care nurses’ knowledge of federal and North Carolina state legislation regarding confidentiality.

Methods
This descriptive, qualitative study included 12 critical care nurses who were asked to describe their knowledge of federal confidentiality legislation and specific knowledge of North Carolina’s confidentiality legislation.

Results
Critical care nurses were knowledgeable about federal confidentiality laws but demonstrated a need for further education about state-specific legislation.

Conclusion
Nurses’ application of confidentiality legislation demonstrates their knowledge of confidentiality legislation. To continue the trusting relationship that nurses have traditionally held with patients and patients’ families, it is imperative for nurses to remain current about confidentiality legislation. Through education both before and after licensure, correct application of legislation can be achieved. Further research can aid in exploring the intersection between health care legislation and ethics. (American Journal of Critical Care. 2016;25:222-227)
In critical care units, health care professionals face dilemmas involving the confidentiality of health information. Often, patients are incoherent or physically unstable and thus unable to make autonomous decisions about their confidential health information. Families, out of love and concern, have a need for information about their relatives. This need can become complicated for patients, patients’ families, and health care workers because of confidentiality legislation. Professional codes of ethics help guide health care workers’ values and practice related to confidentiality. Legislative standards guide practice and help to diminish mistrust and misunderstanding of health care workers by health care consumers. It is imperative to begin to understand critical care nurses’ knowledge of the concept of confidentiality. The intersection of health care legislation and ethical principles is important to practice. Beginning to explore that intersection must start with understanding nurses’ knowledge of the legislation. This research is focused on critical care nurses’ knowledge of federal and North Carolina confidentiality legislation.

Protection of health information became a national incentive under the George H. W. Bush administration in the 1990s and continued through the Clinton administration. The Health Insurance Portability and Accountability Act (HIPAA) was enacted as PL104-191 in 1996 and recorded in the Code of Federal Regulations in 2000. After some modification, compliance was required by April 14, 2003. This legislation provides a legal minimum standard to protect the privacy and confidentiality of health care recipients. Individual state boards of nursing address the concept of patient confidentiality. According to the North Carolina State Board of Nursing, registered nurses are to “safeguard confidentiality.” Protection of health information is addressed in the North Carolina Declaration of Patient Rights. North Carolina statutes regarding confidentiality are broad and do not explicitly define the maintenance of confidential patient information. Federal legislation preempts North Carolina state law in this instance; thus health care workers and covered entities must defer to federal law when in need of legislative guidance for protection of health information.

Methods

A qualitative approach using open-ended questions was used to elicit critical care nurses’ knowledge of confidentiality legislation. Upon receiving approval from the University of North Carolina at Chapel Hill’s Public Health and Nursing Institutional Review Board, informed consent was obtained. Participants were assigned pseudonyms to protect their confidentiality and are used in this write-up for clarity between participant data. Participants were recruited from central regions of North Carolina by flyer, word of mouth, and snowball sampling. Interviews were conducted until saturation of data was achieved (n = 12). Twelve respondents had more than 2 years of critical care experience. Data were collected via face-to-face interviews and a telephone interview 1 week later to allow the opportunity to add further information or clarify information already provided. Nurses were asked to describe their general knowledge of confidentiality legislation as well as legislation specific to North Carolina.

The data were analyzed by using content analysis, then coded using keywords from the language of the participants, paraphrased, and placed into emerging categories. Common to naturalistic qualitative research, reliability and validity were replaced by values of credibility, transferability, dependability, and confirmability. Prolonged engagement with the data optimized the credibility of the findings. A clear and concise audit trail enhanced dependability and confirmability. Thick, rich description of the data and the use of quotes from participants in the write-up confirmed that the findings reflected the data and enhanced the transferability of the findings.

Often critical care patients are unable to participate in decisions about their confidentiality.
Results

All of the participants noted that health information was protected. Lilly commented that “all patient information is protected from anyone that’s not directly involved in that patient’s care.” Evelyn’s description of confidentiality law was more specific. She stated,

Again, we are responsible not to divulge patient information to anyone that is not authorized by the patient. Again, in practice, sometimes the patient cannot authorize anybody and we have to go to the next of kin, to the best we can find.

Half of the participants further specified that confidentiality legislation limited sharing information with anyone who was not directly involved in the patient’s care. Janelle commented, “That means that we’re not sharing information about that patient with other people that don’t need to know that information if they’re not involved in helping that person get well.”

When asked to identify confidentiality legislation, all of the nurses referred to HIPAA. Hannah responded, “Well, you know, HIPAA—that’s probably the biggest one. HIPAA—don’t say anything, don’t talk.” Charlotte further clarified that HIPAA applied to physicians’ offices and insurance companies, sharing of information over the telephone and, in general, patients have to give permission for someone else to get information about their medical condition or their position. I know that physician’s offices can’t, they have, every visit you make, you sign saying that they can give information to insurance companies. It impacts whenever they are calling with lab results back to you. They have to have permission whether they can leave a message on your answering machines.

Hannah indicated specific knowledge of HIPAA in her discussion of incidental breach when visitors walk past nurses during shift report. She stated, “It’s a breach. It’s a breach but I guess an understandable breach in that you were doing what you were supposed to do appropriately; however, the information still got out.” All of the participants indicated knowledge that there were individual and institutional penalties related to breach of confidentiality.

Half of the participants demonstrated familiarity with the concept of in loco parentis, Latin for “in the place of a parent.” In their discussions of sharing information about patients unable to make autonomous decisions, Hannah and Charlotte discussed the role of a health care power of attorney (HCPOA). Charlotte commented,

When asked how she handled those situations, Lilly replied, “Usually, I contact the supervisor or someone who knows specifically how that relationship works in terms of when the patient is kind of emancipated from their parents.” No other participants reported caring for minors or others under legal guardianship.

Participants did identify information that is and is not confidential. All of the participants said that they could share “general” information. All included the patient’s condition as part of general information. Beth described general information as: “the patient is stable, we are monitoring the patient.” Donna said, “They’re resting comfortably. They are getting better. They are holding their own; very general comments.” Charlotte stated that she “would not give them much of anything.” She commented, “A lot of nurses will just say, ‘I’m sorry we can’t give out any information, you will have to touch base with the family.’” Less common responses about what information could be shared included assessment and laboratory data, nutrition, fluid status, disease processes, and the plan of care.

Ten participants said that they could not share any information that was considered socially

When asked to identify confidentiality legislation, all of the nurses referred to HIPAA.
stigmatic. Disease processes considered socially stigmatic included diagnoses of HIV infection, AIDS, cancer, substance abuse, or sexually transmitted diseases. Gail recalled this story:

We had a case just last week where we were sure the family didn’t know that the patient had HIV. So we had to be careful. I don’t think it came across that we were being mean, I think we handled that well. So in that case, even though the person is their contact person by law, you can’t tell them everything.

Hannah indicated that she perceived socially stigmatic information as more protected than other health information. Similarly, Lilly stated, “I think the HIV, I would probably be a little more protective of because that has to do with personal choices the patient’s made or possibly made.” Charlotte disagreed: “Everything is supposed to be kept confidential. You think of it as needing to be more confidential. It’s actually in practice; everything is as confidential as that.”

Federal legislation requires that protected health information be released when the health and benefit of the public or private citizens is affected. Contrary to the legislation, Gail stated, “I don’t think it works that way. I think I would be legally compelled to not say anything.” Kristen specified that “suicide and abuse” required reporting. Janelle’s statement conveyed knowledge of HIPAA13:

If it is affecting the health of another person, TB [tuberculosis], things that the other person needs to look to see if they are contracting a disease too, it’s regulated; TB and communicable diseases that can be passed on. The health department requires that.

Laboratory and other test results as well as the medical record were also considered confidential. Information considered least confidential was assessments, physicians’ names, skin care, and treatments. Hannah specified that confidential information included, "If they have family issues, diagnosis, medication, what’s happening with them at that time, skin care, anything having to do with the patient."

Nurses’ Knowledge of North Carolina State Legislation

Knowledge of North Carolina law varied among participants. “I don’t know” was the most common response (n = 8) when nurses were asked if North Carolina had state-specific confidentiality legislation. Frances was unsure about specific legislation but noted that North Carolina law was affected by other regulations. “I’m sure they do with HIPAA and the NC Board of Nursing.” Evelyn shared more detailed knowledge, noting that at times federal legislation supersedes state legislation: “I figure HIPAA covers. Between HIPAA and [hospital] practice it pretty much took care of what I needed to know.” Evelyn believed that North Carolina had also established common-law marriage legislation. She said: “I think it’s 7 years . . . they call it common-law wife or common-law spouse and I think its 7 years.”

North Carolina does not recognize common-law marriages; therefore, long-term partners or significant others are not legal next of kin.

According to North Carolina general statute regarding privilege,14 communication between patients and nurses is considered privileged and indicates that no disclosure of patient-nurse communication should occur except under the direction of a superior or district court judge for purposes of justice. None of these nurses verbalized knowledge of privileged communication legislation. Anne commented, “It’s not, I don’t think it is . . . and yet there are some things that we have to be able to ask them to take care of them. There again, there is that level of trust that is established.” When specifically asked, Irene indicated the most accurate perception. She stated, “You know I’ve never thought, I think it depends on what they say. With some, there are a lot of private things they disclose to us, but yes, I think as their caregiver, that is privileged.” None of the nurses acknowledged duty-to-warn legislation, the Declaration of Patient Rights or the Patient’s Bill of Rights.15

This study begins to fill gaps in the literature in regard to what nurses do and do not know about state legislation. The nurses were unable to specify whether or not North Carolina had specific confidentiality legislation, but they correctly assumed that HIPAA preempted state legislation when HIPAA was more stringent.9 Nurses did not discuss the Patient’s Bill of Rights or the requirement by the North Carolina general statute15 that requires that the Patient’s Bill of Rights be publically displayed in all facilities. Irene indicated that she considered nurse-patient communication privileged but she did not say that it was a legal obligation as specified in the North Carolina general statute regulating nurse privilege.14 These regulations are important to the protection of patient rights and the protection of communication with patients. It is imperative for nurse leaders to recognize the importance of this legislation and to communicate these rights and privileges to nurses in direct care settings.

Nurses’ Knowledge of Federal Legislation

This study was the first to explore critical care nurses’ knowledge of confidentiality legislation.

In North Carolina, communication between patients and nurses is privileged.
Based on the present findings, it can be hypothesized that the continuing education about confidentiality legislation provided to these nurses was effective. Findings indicated that nurses are generally knowledgeable about federal legislation (HIPAA) as the primary rule governing patient confidentiality. Participants clearly showed knowledge of HIPAA restrictions. Their descriptions of confidential patient information were similar to those presented in the literature.

Although they did not specifically use the legal term in loco parentis, the nurses were able to describe this concept in regard to with whom they shared confidential information in the absence of the patient. Lilly in particular demonstrated knowledge of this concept in her discussion of emancipated minors. Her description indicated an in-depth understanding of the general rules of HIPAA. Critical care nurses in this study also indicated that they released information on a “need to know” basis, indicating knowledge of HIPAA legislation that requires information to be released on a “minimally necessary” basis. Although none of the nurses mentioned the American Nurses Association (ANA) Code of Ethics, their practice of releasing only minimally necessary information is consistent with the ANA’s recommendation regarding the nurse’s role in patient confidentiality. Although it is impossible to consider every possible situation and detail of patient information, the study provides a list of items that the nurses deemed confidential. These items should serve as a starting point for nurse leaders and policy makers when writing and revising confidentiality policy.

The nurses in this study conveyed familiarity with incidental breach legislation as outlined by HIPAA. They indicated that shift reports and rounds were times that incidental breaches of information occurred. These findings are similar to those of other researchers, who noted that information is often overheard by patients’ families and visitors. The findings indicate that nursing leaders may need to evaluate current policies and establish a plan of action regarding the coordination of shift report and visitation policies while keeping patients’ families involved in the care of their loved ones.

Limitations
The sample used in this study was 12 critical care nurses from central North Carolina who were white, natural-born citizens. The experiences of nurses from other types of practice and geographic locations were not the focus of this study and therefore such information was not collected. Demographic data such as marital status, age, and shift assignment were also not the focus of this study, and their impact on the findings was not explored. Nurses were not asked about their previous education regarding confidentiality law or ethics. It is therefore unknown what level, type, and frequency of education about confidentiality legislation and ethical principles the nurses had. All of the participants’ education related to confidentiality legislation most likely came from institutional resources. Although not generalizable, the findings can be transferable as readers may connect or relate their own perceptions and experiences to the findings of this study.

Implications
Providing simulation and scenarios in a structured, safe environment would allow students to apply confidentiality regulations. Increased access to legislative regulations in clinical settings may also increase understanding and applicability. Replication of this study to explore a sample and setting outside of central North Carolina to explore the impact of location on nurses’ knowledge of confidentiality legislation and the impact that these factors have on their practice would be useful. Future research should focus on the decision-making process at the bedside, where decisions are made without much time to consider all of the legal nuances and ethical theories related to sharing or not sharing confidential health information.

Conclusion
Critical care nurses’ actions are at the heart of patient confidentiality. Nurses should be encouraged to share information with patients and patients’ family members within regulations of state-specific and federal legislation. Provision of prelicensure education and regular reinforcement of knowledge related to state and federal legislation is needed for all nurses. Knowledge about state and federal legislation and codes of ethics affects decisions regarding confidential health information. To continue the trusting relationship that nurses have traditionally held with patients and patients’ families, it is imperative for nurses to remain current about confidentiality legislation. This exploration of critical care nurses’ knowledge of confidentiality legislation provides insight into their understanding and application of legislation.

ACKNOWLEDGMENTS
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FINANCIAL DISCLOSURES
None reported.

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For more about patient confidentiality, visit the Critical Care Nurse Web site, www.ccnnonline.org, and read the article by McGowan, “Patients’ Confidentiality” (October 2012).

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Background  Patients in intensive care units are likely to have limited mobility owing to hemodynamic instability and activity orders for bed rest. Bed rest is indicated because of the severity of the disease process, which often involves intubation, sedation, paralysis, surgical procedures, poor nutrition, low flow states, and poor circulation. These patients are predisposed to the development and/or the progression of pressure ulcers not only because of their underlying diseases, but also because of limited mobility and deconditioned states of health.

Objective  To assess whether treating high-risk patients with a prophylactic sacral dressing decreases the incidence of unit-acquired sacral pressure ulcers.

Methods  An evidence-based tool for identifying patients at high risk for pressure ulcers was used in 3 intensive care units at an urban tertiary care hospital and academic medical center. Those patients deemed at high risk had a prophylactic sacral dressing applied. Incidence rates were collected and compared for the 7 months preceding use of the dressings and for 7 months during the trial period when the dressing was used.

Results  After the sacral dressing began being used, the number of unit-acquired sacral pressure ulcers decreased by 3.4 to 7.6 per 1000 patient days depending on the unit.

Conclusions  A prophylactic sacral dressing may help prevent unit-acquired sacral pressure ulcers. Implementation of an involved care team with heightened awareness and increased education along with a prophylactic sacral dressing in patients deemed high risk for skin breakdown are all essential for success. (American Journal of Critical Care. 2016;25:228-234)
Patients in intensive care units (ICUs) are predisposed to pressure ulcers because of limited mobility and the severity of their disease processes. Pressure ulcers result from pressure or a combination of pressure and shear, usually over bony prominences, and cause localized injury to the skin and underlying tissues. The prevalence of pressure ulcers in acute care settings is estimated at 12% to 19.7%, of which 20% occur on the sacrum or coccyx. In ICUs, pressure ulcers rates can occur in 14% to 42% of patients. For patients, pressure ulcers can be painful, embarrassing, isolating, and, in some cases, life-threatening.

The standard of care to prevent pressure ulcers includes routine repositioning to offload pressure points, moisture management, use of support surfaces, and assessment of nutritional requirements by registered dietitians. Despite these practices designed to mitigate risk, pressure ulcers continue to develop in many high-risk ICU patients. In practice, pressure ulcers are indicators of quality of care. The Joint Commission considers prevention of health care–associated pressure ulcers a National Patient Safety Goal. The Institute for Healthcare Improvement included pressure ulcer prevention in its 5 Million Lives Campaign. More recently, the federal government identified pressure ulcers as one of the hospital-acquired conditions included in the Agency for Healthcare Research and Quality composite measure PSI-90. Hospital-acquired conditions are included in 2 pay-for-performance programs under the Patient Protection and Affordable Care Act that have great implications for hospital finances: penalties for hospital-acquired conditions and value-based purchasing incentives.

Treatment of pressure ulcers is expensive, with estimates of the cost at a mean of $1200 to $1600 per day. The Centers for Medicare and Medicaid Services no longer reimburses facilities for pressure ulcer care when the ulcers are acquired in the hospital. Starting in 2015, hospitals that rank among the worst 25% for hospital-acquired conditions, including pressure ulcers, will see their reimbursement rates decline. Reducing the incidence of pressure ulcers would not only reduce the negative physical and psychological impact on patients and improve patients’ outcomes, it might also reduce costs and increase reimbursement for hospitals. Yet, despite the widespread recognition of the need to prevent pressure ulcers in critical care patients, challenges remain in the ability to prevent them. Recent studies indicate that silicone dressings may hold promise for prevention of pressure ulcers. ICU patients who received a soft silicone multilayered foam dressing on the sacrum showed significantly fewer pressure ulcers.

This study sought to evaluate the effects of a prophylactic silicone adhesive hydrocellular sacral foam dressing on incidence of sacral pressure ulcers among high-risk ICU patients. The product for the trial was chosen because the facility already used Allevyn (Smith & Nephew) dressings of various sizes and shapes for care of skin tears with good results and the nurses were already familiar with this type of product. The particular dressing used in this trial is specifically designed for use on the difficult-to-fit coccyx area.

### Methods

#### Setting

This study was conducted in an urban tertiary care academic medical center that is also a level I trauma center with 951 licensed acute care beds. Three ICUs at the institution participated in the study: the surgical coronary care unit (SCCU), a 9-bed surgical cardiac ICU; the medical coronary care unit (MCCU), a 9-bed medical cardiac ICU; and a 25-bed medical ICU (MICU). The SCCU generally provides care for patients after coronary artery bypass surgery, valve replacement or repair.
implantation of a ventricular assist device, heart transplant, or extracorporeal membrane oxygenation cannulation. The MCCU provides care for patients who had a recent ST-segment elevation myocardial infarction, cardiogenic shock, or heart failure with decompensation and for patients who require optimization before cardiothoracic surgery. The MICU generally provides care for patients with liver failure, respiratory failure requiring intubation and mechanical ventilation, pulmonary hypertension, septic shock, multisystem organ failure, and acute respiratory distress syndrome. The hospital’s standard mattress in all 3 of these ICUs was the AtmosAir 9000 (KCI).

**Sample**

The study was approved by the institutional review board and granted a waiver of consent. All adults, aged 18 years and older, and admitted to any of these ICUs were screened for inclusion in the trial on the basis of their risk factors for skin breakdown. Patients assessed as having any 1 of the following criteria were included in the study: surgery longer than 4 hours or cumulative surgeries longer than 6 hours; cardiac arrest during this admission; vasopressor use for more than 48 hours; shock; sepsis; or multiorgan dysfunction syndrome.

If patients did not meet the aforementioned singular criteria, they were evaluated for the following: age more than 65 years old; bed rest; traction; diabetes; liver failure; hemodynamic instability; body mass index (calculated as weight in kilograms divided by height in meters squared) less than 18.5 (underweight) or greater than 40 (morbid obesity); malnutrition (prealbumin < 20 mg/dL, albumin < 2.5 g/dL, nothing by mouth > 3 days); spinal cord injury (quadruplegia/paraplegia); sedation/paralysis for more than 48 hours; history of pressure ulcers; mechanical ventilation for more than 48 hours; nitric oxide ventilation; drive lines (left or right ventricular assist device balloon pump, extracorporeal membrane oxygenation); history of vascular disease; expected length of stay greater than 5 days; intermittent hemodialysis/continuous venovenous hemodialysis; Braden score 12 or less; or orthopedic injuries. Any patient who screened positive for 5 or more of these conditions was included in the study.

Patients with any of the following conditions were excluded from the study: urinary or fecal incontinence not managed with a urinary catheter or fecal management system, weeping edema or anasarca, diaphoresis in sacral area, or preexisting sacral pressure ulcer. Patients who were excluded from the study could still receive the study dressing if a wound ostomy and continence nurse (WOCN) recommended it, but those patients were not included in the evaluation.

**Design**

A prospective, nonrandomized, quasi-experimental observational study was conducted to compare ICU-acquired sacral pressure ulcers in patients assessed at high risk for development of pressure ulcers before and after implementing prophylactic use of silicone adhesive hydrocellular sacral foam dressings. Baseline data on the daily incidence of pressure ulcers on the sacrum, buttocks, and coccyx were collected for the 7 months before implementation of the dressings, from October 2011 to April 2012. During this 7-month period, a screening tool to determine which patients were at high risk for pressure ulcer development on the sacrum, buttocks, and coccyx was developed after an extensive literature review. This tool was validated by the 3 WOCNs employed by the facility. In preparation for intervention data collection, in February 2012, each participating ICU conducted an informal evaluation of the screening criteria for risk of pressure ulcers and the application of the sacral dressing as prophylaxis. Registered nurses were asked to assess patients using the screening criteria and apply the dressing as pressure ulcer prophylaxis in patients who met screening criteria. The nurses were also asked to evaluate the dressing for ease of application, removal, wear time, patient comfort, ease of repositioning, and patient safety. Overall, the nurses rated the aspects of the sacral dressing positively. During this study preparation, fewer than 10% of patients had clear fluid-filled blisters related to moisture develop under the sacral dressing. Following the review of these patients by the WOCN, the screening criteria and follow-up assessment criteria were clarified to minimize the risk for blistering under the dressing during the intervention phase. Before the intervention phase, staff in all 3 units and the cardiothoracic operating room, where patients had dressings applied before their procedure, received education regarding the dressing criteria tool, dressing application (Table 1), the data collection tool (Figure 1), and dressing removal.

The intervention phase of this study occurred from May through November 2012. During the trial period, each adult patient who was admitted to any of the 3 ICUs was assessed by a registered nurse upon arrival to the unit and screened for study eligibility. Patients who met inclusion criteria received a prophylactic sacral dressing. The dressing used in this study was the Allevyn Gentle Border Sacrum Dressing manufactured by Smith & Nephew. Data

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**Nurses evaluated the dressing for ease of application, removal, wear time, patient comfort, ease of repositioning, and patient safety.**
on ICU-acquired pressure ulcers were collected daily by clinical nurse specialist and registered nurses for each unit.

Once the sacral dressing was applied to a patient, an assessment was performed by the primary nurse every shift (minimum every 12 hours) and documented on the data collection tool and in the electronic medical record. Skin assessments were completed per the hospital’s standard of nursing care and included peeling back the sacral dressing to perform a full skin inspection underneath. Also documented on the data collection tool were assessments of the skin condition under the dressing, whether the dressing was reapplied or changed, and the end date of the patient’s participation either because the dressing was removed or because the patient was transferred out of a participating ICU. Each patient had a data collection tool for each shift. Completed data collection tools were collected weekly by each unit’s clinical nurse specialist.

To ensure appropriate assessment and clinical care for patients with the sacral dressing, a mark was placed next to the patient’s name on the unit’s patient assignment board in the nurses’ break room. The sacral dressing was changed every 3 days while the patient remained in the study. Any patients who had exclusion criteria develop after application of the sacral dressing during this study had the dressing removed. The removal date was noted on the data collection tool as the end date of the patient’s participation. If, during the study, any skin changes occurred under the dressing, the dressing was removed unless continued use was recommended by a WOCN. Each event that required dressing removal was investigated by a WOCN, and if any further treatment was recommended, it was implemented promptly. In addition, because the study included patients at very high risk for skin breakdown, any skin breakdown or redness was noted and a WOCN evaluated further use of sacral dressing treatment.

Statistical Analysis

Data were entered into an Excel (Microsoft Corp) spreadsheet and imported into IBM SPSS Statistics 19 (IBM SPSS) for analysis. Descriptive statistics were used to characterize the dressing use. Pressure ulcer rates were calculated by using the industry’s standardized rate per 1000 patient days. Differences in pressure ulcer rates were obtained by calculating incidence rate ratios and confidence intervals. P values were calculated by using a χ² test.

Results

Data from all 3 units (SCCU, MCCU, and MICU) were combined for analysis. Of the 584 patients assessed for inclusion, 243 (41.6%) had a sacral dressing applied but completed data were received on only 200 of those patients (Figure 2). Among the 243 who had a sacral dressing applied, surgery longer than 4 hours or cumulative surgeries longer than 6 hours (32.5%, n = 79) and sepsis (23.5%, n = 57) were the most common singular inclusion criteria (Figure 3). Table 2 lists the characteristics for the 132 patients who met inclusion criteria for 5 or more factors and had a sacral dressing applied. The mean duration for a patient to have a dressing in place was 3.26 days (SD, 3.17, n = 200), with a range of 0 to 24 days. In all, 71.5% (n = 143) of patients had a dressing applied for 3 or fewer days.

Depending on the unit, implementation of the sacral dressing reduced unit-acquired sacral pressure ulcers anywhere from 3.4 to 7.6 per 1000 patient days. The SCCU had the most dramatic reduction at 7.6 per 1000 patient days, the MCCU had a reduction of 3.4/1000 patient-days, and the MICU reduced rates by 3.6 per 1000 patient days (Table 3).
**Figure 1** Data collection tool.

Abbreviations: DTI, deep tissue injury; PU, pressure ulcer; WOCN, wound ostomy continence nurse.

Five patients experienced unanticipated skin issues during the trial. Two patients had a deep tissue injury (DTI) develop, 1 had a stage I pressure ulcer develop, and 1 had a blister develop on the sacrum. In all of these cases, the dressing was immediately removed upon discovery of the skin changes, a WOCN was consulted, and further treatment was implemented, if recommended by the WOCN. The fifth case was a DTI located on the patient’s left buttock that resulted from pressure caused by the patient lying on a partially dislodged sacral dressing. Upon discovery of the altered dressing integrity, this patient was treated appropriately with a wound care consultation and the application of a mild topical vasodilator, and the DTI resolved.
**Discussion**

Minimizing pressure ulcers is an important issue for the management of critically ill patients. The intention of the study was to see if the use of a new product on the market would improve outcomes in our patients at high risk for pressure ulcers. Study findings revealed that during the 7-month trial, use of the dressing led to decreases in the incidence of pressure ulcers on the sacral, coccyx, and buttock area in all 3 ICUs. These findings suggested that the dressing could decrease cost for institutions and improve patient care, contributing to the body of knowledge about interventions to minimize the risk of pressure ulcers. Our results were similar to those of Santamaria et al,13 Chaiken,15 and Walsh et al.14 Education and reminders to the bedside staff on exactly how to apply and use the dressing are imperative to the prevention of pressure ulcers in patients.

**Limitations and Strengths**

Because of the nature of the prospective study design, demographic information was not collected. This lack of demographic data prevented a direct comparison between the pretrial population and the population during the trial. Other risk factors for pressure ulcers, not related to the prophylactic dressing, may have differed between these 2 populations, thus biasing the results of this trial. Additionally, the study sample was nonrandomized; it was a convenience sample that looked only at feasibility. Interrater reliability could not be assessed because repositioning of patients was not monitored. Documentation was incomplete in 43 of the patients who had the dressing applied, making it impossible to track the reason for application and wear time in those patients. Multiple initiatives were taking place during this time frame that also focused on prevention of pressure ulcers. A multidisciplinary hospital-acquired pressure ulcer committee was developed in September 2011 that evaluated wound care practices, policies, and products and implemented changes, all with the common goal of decreasing the incidence of pressure ulcers. Dermal defense champions were chosen in February 2012, and their focus was to receive monthly education on pressure ulcer prevention and then relay that information at the unit level to staff nurses. The units had increased education and awareness during this period, which caused more active participation. The decrease in pressure ulcer incidence during the intervention phase improved patients’ outcomes.

**Conclusion**

The results of this study indicated that a prophylactic sacral dressing may prevent ICU-acquired sacral pressure ulcers. Future studies could evaluate the effects of prophylactic dressings in conjunction with a critical care bundle for prevention of pressure ulcers that addresses nutritional status and frequent repositioning. Conducting a randomized controlled trial would be beneficial for further
analysis of the effects of the dressing itself. It would be useful to study the cost-effectiveness of such interventions. Also, it would be useful to study prophylactic dressings on other body areas prone to pressure damage, such as around devices or specialty equipment.

FINANCIAL DISCLOSURES
Some of the Allevyn dressings were donated by the manufacturer, Smith & Nephew (120 dressings comprising approximately 50% of 1 month’s supply). However, this donation covered only a portion of necessary supplies. Additional supplies were provided by Thomas Jefferson University Hospital. Smith & Nephew played no role in the design of the research study or the collection of data and was not considered a contributing partner or coauthor.

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Table 3
Improvements seen in each unit in the study during the Allevyn trial period

<table>
<thead>
<tr>
<th>Unit</th>
<th>Pressure ulcer incidence (per 1000 patient days) Before trial</th>
<th>Rate difference (per 1000 patient days)</th>
<th>Incidence rate ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical coronary care</td>
<td>13.00</td>
<td>5.38</td>
<td>7.62</td>
<td>0.41</td>
<td>0.16-1.09</td>
</tr>
<tr>
<td>Medical coronary care</td>
<td>7.40</td>
<td>3.96</td>
<td>3.44</td>
<td>0.54</td>
<td>0.16-1.78</td>
</tr>
<tr>
<td>Medical intensive care</td>
<td>6.98</td>
<td>3.40</td>
<td>3.58</td>
<td>0.49</td>
<td>0.14-1.73</td>
</tr>
</tbody>
</table>

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CAUSE OF DEATH OF INFANTS AND CHILDREN IN THE INTENSIVE CARE UNIT: PARENTS’ RECALL VS CHART REVIEW

By Dorothy Brooten, RN, PhD, JoAnne M. Youngblut, RN, PhD, Carmen Caicedo, RN, PhD, Lynn Seagrave, RN, BSN, G. Patricia Cantwell, MD, and Balagangadhar Totapally, MD

Background  More than 55,000 children die annually in the United States, most in neonatal and pediatric intensive care units. Because of the stress and emotional turmoil of the deaths, the children’s parents have difficulty comprehending information.

Objectives  To compare parents’ reports and hospital chart data on cause of death and examine agreement on cause of death according to parents’ sex, race, participation in end-of-life decisions, and discussion with physicians; deceased child’s age; unit of care (neonatal or pediatric); and hospital and intensive care unit lengths of stay.

Methods  A descriptive, correlational design was used with a structured interview of parents 1 month after the death and review of hospital chart data. Parents whose children died in intensive care were recruited from 4 South Florida hospitals and from Florida Department of Health death records.

Results  Among 230 parents, 54% of mothers and 40% of fathers agreed with the chart cause of death. Agreement did not differ significantly for mothers or fathers by race/ethnicity, participation in end-of-life decisions, discussions with physicians, or mean length of hospital stay. Agreement was better for mothers when the stay in the intensive care unit was the shortest. Fathers’ agreement with chart data was best when the deceased was an infant and death was in the pediatric intensive care unit.

Conclusions  Death of a child is a time of high stress when parents’ concentration, hearing, and information processing are diminished. Many parents have misconceptions about the cause of the death 1 month after the death. (American Journal of Critical Care. 2016;25:235-242)
The death of a child is devastating for the child’s parents. In the United States, 55,000 infants and children die annually, most in neonatal or pediatric intensive care units (NICUs and PICUs). These ICUs, with their high noise levels, equipment, and fast pace, can impose additional stressors on parents in a time of crisis. Because of the stress and emotional turmoil that parents experience around the time of death of their infant or child, the decisions they may need to make, and the added stress of the ICUs, parents often have difficulty comprehending or grasping the information shared with them. Differences in language, cultures, and educational levels can add to difficulties in comprehension and in making end-of-life decisions.

Studies on parents’ understanding of information shared around the time of their child’s death most often have been retrospective, requiring parents to recall information 1 to 10 years after the death, and study samples have consisted mainly of white, English-speaking participants. The primary aim of this study was to compare the cause of an infant’s or a child’s death as reported by parents in 3 racial/ethnic groups (white, black, Hispanic) with cause of death reported in hospitals’ chart data. A secondary aim was to examine differences between each child’s mother and father according to the parents’ race/ethnicity (white, black, Hispanic), participation in end-of-life decisions, and discussion with physicians; deceased child’s age group; unit of care (NICU, PICU); and length of hospital and ICU stay.

Causes of Death

Leading causes of death in infants differ from those in children. Most deaths in infants in the United States (56.1%) are attributed to 5 leading causes: congenital anomalies and genetic disorders (20.1%), disorders related to prematurity and low birth weight (16.9%), sudden infant death syndrome (8.2%), maternal complications of pregnancy (6.3%), and accidental or unintentional injury (4.6%). Leading causes of death in children 1 to 19 years old are accidents or unintentional injuries (38.8%), assaults (12.4%), malignant neoplasms (8.6%), suicide (8%), illnesses and diseases (7.7%), and congenital anomalies or genetic disorders (4.7%). No matter the cause, the death of an infant or child is a devastating, stressful, high anxiety situation for the parents, especially deaths that occur in ICUs.

Parents’ Distress and Information Recall

For the parents, high levels of stress and distress around the time of death of an infant or a child are associated with problems in comprehending or grasping information provided. Lannen et al studied parents’ ability to absorb information that the parents’ child had incurable cancer and tried to identify factors associated with the parents’ ability to absorb the information. Of the 449 parents in the study, 60% reported being able to absorb the information that their child’s cancer was incurable, 29% reported they were not, and 12% stated they did not receive any information. In an earlier study of 46 parents within 3 years of diagnosis of cystic fibrosis in their children, 76% lacked understanding of the disease, although more than 33% admitted having understood or remembered something about what the physician had told them. Meert et al found that because of the emotional turmoil associated with a child’s death, parents had difficulty comprehending information provided at that time.

Methods

Research Design

The data reported here are from a longitudinal study on parents’ health and functioning after the ICU death of an infant or child. The study was approved by the appropriate institutional review boards and was carried out according to the ethical
standards set forth in the Helsinki Declaration of 1975. Parents (white non-Hispanic, black non-Hispanic, Hispanic or Latino) who had lost a child in the NICU or PICU were identified by clinician coinvestigators at each of 4 hospitals in South Florida or identified through death records from the Florida Department of Health, Office of Vital Statistics.

A letter was sent by the study project director to each family (in Spanish and English) describing the study and containing the study telephone number should parents choose not to participate. For parents who had not responded, the letter was followed by a telephone call 2 weeks later by research assistants who screened parents for inclusion and exclusion criteria, described the study, answered parents’ questions, obtained verbal consent for parents who chose to participate, and scheduled a first interview, where written consent was obtained. Parents were included if they were able to understand spoken English or Spanish, had a newborn from a singleton pregnancy who lived for more than 2 hours in the NICU, or had a deceased child 18 years or younger who lived at least 2 hours in the PICU. Exclusion criteria were a multiple pregnancy with a deceased newborn, child living in a foster home before hospitalization or whose injury was suspected child abuse, and parent’s death in the illness or injury event (eg, motor vehicle crash).

Measures and Data Collection

All data were collected by bilingual (English and Spanish) research assistants who were health professional students with advanced clinical degrees and were trained in study methods. Interviews with parents in English or Spanish were conducted in the parents’ home at a time convenient for the parents 1 month after death of the infant or child. By 1 month after the death, the initial shock and numbness have subsided, funeral rituals have been completed, and friends and family have returned to their own lives but circumstances surrounding the death can be recalled accurately. Parents were asked specific questions about the death, decisions and participation in these decisions around the time of the death, treatments, and the cause of the death. Questions included the following: Did you discuss the child’s progress with the physician? Was your child resuscitated, and who made this decision? Was any treatment stopped before your child’s death and who made this decision? What was the cause of the death. Answers to these structured questions and demographic data including each parent’s age, sex, race/ethnicity, education, income, marital status (single, partnered), and employment status were recorded at the time of the interview on standard data collection forms by the research assistants who conducted the interviews. Hospital chart data included the deceased’s age, race/ethnicity, sex, length of stay in the ICU and in the hospital, treatments, diagnosis at the time of admission, cause of death, and family involvement.

Data Analysis

Data on cause of the infant’s or child’s death collected from the hospital chart data and parent’s report was determined by consensus (yes, no, similar) by a panel of 2 physicians and 2 nurses with doctorates. Initially each panel member independently scored agreement (yes, no, similar) on causes of death from hospital chart data with that of the parent’s reports. Any scoring inconsistencies were reviewed and discussed by the total panel until consensus was reached.

Categorical data were summarized as frequencies and percentages; continuous data, as means and standard deviations. Agreement (concordance) within parent couples was compared. All other analyses were done for mothers and fathers separately. Agreement within parent couples was compared on each parent’s race/ethnicity, discussions with physicians on the prognosis of the deceased infant or child, the parent’s participation in end-of-life decisions, the deceased child’s age group, and unit of care (NICU, PICU) by using $\chi^2$ analyses. Mean lengths of hospital and ICU stay were compared across agreement (concordance) groups by using 1-way analysis of variance. The $P$ level for statistical significance was set at .05.

Results

Sample

Of 318 eligible families contacted, 146 refused to participate in the study (46%), and 172 agreed to participate (54%). The final study sample (Table 1) consisted of 230 parents (162 mothers, 68 fathers) whose infant or child died in the NICU ($n = 72$) or the PICU ($n = 100$). Fathers were a mean of 5.6 years older than the mothers. A total of 78% of the parents were minorities (Hispanic and black). Most parents were married or living with a partner; more than half of the parents had had some education beyond high school. The majority of families had an annual income less than $50,000.
Table 1
Characteristics of the parents

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) of parentsa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (N = 230)</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>31.7 (7.8)</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>82 (36)</td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>50 (22)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>98 (42)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>&lt; High school</td>
<td>30 (13)</td>
</tr>
<tr>
<td>High school graduate</td>
<td>56 (24)</td>
</tr>
<tr>
<td>Some college or vocational-technical training</td>
<td>81 (35)</td>
</tr>
<tr>
<td>College degree</td>
<td>62 (27)</td>
</tr>
<tr>
<td>Partnered</td>
<td>183 (80)</td>
</tr>
<tr>
<td>Employed</td>
<td></td>
</tr>
<tr>
<td>Before death</td>
<td>145 (63)</td>
</tr>
<tr>
<td>After death</td>
<td>96 (42)</td>
</tr>
<tr>
<td>Annual family income,b $</td>
<td></td>
</tr>
<tr>
<td>&lt; 3000-19999</td>
<td>37 (34)</td>
</tr>
<tr>
<td>20 000-49 999</td>
<td>31 (28)</td>
</tr>
<tr>
<td>≥ 50 000</td>
<td>41 (38)</td>
</tr>
</tbody>
</table>

a Because of rounding, not all percentages total 100.
b Data for 109 families; 63 families did not report their income.

Table 2
Characteristics of the deceased infants and children

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) of childrena</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (N = 172)</td>
</tr>
<tr>
<td>Age at death, mean (SD), months</td>
<td>39.4 (64.3)</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
</tr>
<tr>
<td>Infants (&lt;12 months)</td>
<td>104 (60)</td>
</tr>
<tr>
<td>Preschoolers (1-5.9 years)</td>
<td>30 (17)</td>
</tr>
<tr>
<td>School age (6-12.9 years)</td>
<td>17 (10)</td>
</tr>
<tr>
<td>Adolescents (13-18 years)</td>
<td>21 (12)</td>
</tr>
<tr>
<td>Male sex</td>
<td>95 (55)</td>
</tr>
<tr>
<td>Days in hospital, mean (SD)</td>
<td>35.7 (60.9)</td>
</tr>
<tr>
<td>Days in NICU/PICU, mean (SD)</td>
<td>32.7 (58.4)</td>
</tr>
</tbody>
</table>

Abbreviations: NICU, neonatal intensive care unit; PICU, pediatric intensive care unit.
a Because of rounding, not all percentages total 100.

Deceased Children

About half (55%) of the deceased infants and children were boys (Table 2). The mean age of the deceased infant or child was 39.4 (SD, 64.3) months. Mean lengths of hospital and ICU stay were slightly longer for infants in the NICU than for children in the PICU.

Major causes of death varied by chart review and by mothers’ and fathers’ reports. From chart review, the top 4 causes of death were respiratory problems, prematurity, congenital anomalies, and infections (Table 3). The top 4 causes of death reported by mothers were prematurity, respiratory problems, accidental injury, and infection; the top 4 reported by fathers were respiratory problems, infections, surgical complications, and accidental injury.

Agreement of Chart Data and Parents’ Reports

A total of 54% of mothers but only 40% of fathers reported a cause of death that was consistent with data in the hospital chart (Table 4). In 39 of the 56 couples (mother and father of the same child), both parents were in the same agreement category: 16 couples (28%) in the agree with chart category, 15 couples (27%) in the disagree with chart category, and 8 couples (14%) in the close to chart category χ² = 33.9; df = 4; P < .001. In the remaining 17 couples, mothers’ agreement category differed from the fathers’ agreement category. Agreement on chart cause of death did not differ significantly for mothers or fathers by race/ethnicity, by discussing the child’s prognosis with the physician, or by participating in end-of-life decisions. Mothers’ agreement with chart review did not differ significantly by unit of care; however, significantly more fathers of NICU infants were not in agreement compared with fathers of PICU children. Mean length of hospital stay did not differ by agreement for mothers or fathers. Mean length of ICU stay differed significantly by agreement for mothers, but not for fathers. Mean days of ICU stay were shortest for the group of mothers in agreement with chart data and longest for the group of mothers whose stated cause of death did not agree with the chart data. The age group of the infant or child was not significantly related to agreement for mothers, but it was for fathers.
Most fathers of infants (53%) were in agreement with chart data. Most fathers of school-age children (57%) and adolescents (64%) named a cause of death that was close to what was listed in the chart.

According to chart data, most of the 172 deceased infants and children died after resuscitation was unsuccessful, limiting treatments or supportive therapies and withdrawal of life support. Health care providers recorded that 105 families (61%) participated in end-of-life decisions, 13 families (8%) did not participate, and participation of 13 families (8%) was not charted. For 40 families (23%), no end-of-life decision was made. Therapies continued included mechanical ventilation, administration of intravenous fluids, use of a feeding tube, and blood pressure monitoring. Therapies limited included feeding and certain drugs. Do-not-resuscitate orders were present for 47 of the 52 children (90%) who died after treatment was limited. Once life support was removed, 80% of the infants and children died within 1 hour. Most mothers (62%) and fathers (75%) reported that they were with their infant or child at the time of death.

**Discussion**

In this study, we controlled for parents’ recall by collecting data 1 month after the death of the parents’ infant or child. The study sample consisted of a racially/ethnically diverse group of parents who lost an infant or child. The variation in reported causes of death by mothers’ and fathers’ reports and according to chart review might be due to problems in parents’ understanding of the child’s changing condition and prognosis; problems between parents and providers in communication, language, and/or culture; or in recorded chart data. Other research indicates that before the death of their infant or child, parents are frightened by seeing the infant or child in pain and suffering, being unable to communicate with the child, and may be overwhelmed or intimidated by lack of information or by misinformation about the child’s prognosis or impending death. During this time of high stress and anxiety, parents’ concentration is diminished, affecting both receiving and processing of information. Studies have documented parents’ denial of information shared and lack of remembrance of specifics of information shared at this time.

Our findings provide further evidence of this problem. Only 54% of mothers and 40% of fathers agreed with chart data on cause of death. Length of ICU stay, but not length of hospital stay, differed by whether or not mothers’ cause of death agreed with the chart. This was not true for fathers. For the mothers, mean ICU stays were shortest for those who agreed with chart data on cause of death and longest for the mothers who did not agree with the chart data. For more immediate deaths, little to no change may occur in the child’s prognosis and cause of impending death. Their condition, prognosis, and potential cause of death for children whose death is not immediate may change over days. Updates and the flow of this information may be delayed or confusing for mothers who may already be compromised by stress that interferes further with their comprehension of information. In addition, delays or problems may occur in recording such changes in condition in the patient’s chart.

Agreement with chart cause of death did not differ significantly for mothers or fathers by discussions of the child’s prognosis with the physician. Perhaps the reason for this finding is that 84% of the parents reported having had discussions about the child’s prognosis with the physician. Conflicts may occur between parents and health care providers over treatment and end-of-life decisions for the parents’ infant or child. These conflicts may be exacerbated when language and cultural differences exist between parents and health care providers. Studies have indicated that blacks and Hispanics prefer to make decisions as a family group, whereas whites prefer autonomy in decision making. Hispanic Americans reportedly rely on physicians’ judgment. Blacks reportedly hold a belief in miracles from God and are more reluctant to make end-of-life decisions. However, in our sample of 78% minority parents, more than 60% of the parents made end-of-life treatment decisions for their

### Table 3

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>Chart (N = 172)</th>
<th>Mother (n = 157)</th>
<th>Father (n = 67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory</td>
<td>46 (26)</td>
<td>25 (16)</td>
<td>16 (24)</td>
</tr>
<tr>
<td>Infection</td>
<td>20 (12)</td>
<td>17 (11)</td>
<td>10 (15)</td>
</tr>
<tr>
<td>Prematurity</td>
<td>32 (19)</td>
<td>31 (20)</td>
<td>6 (9)</td>
</tr>
<tr>
<td>Congenital anomalies</td>
<td>29 (17)</td>
<td>15 (10)</td>
<td>6 (9)</td>
</tr>
<tr>
<td>Genetic disorders</td>
<td>2 (1)</td>
<td>10 (6)</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Cancer</td>
<td>11 (6)</td>
<td>9 (6)</td>
<td>4 (6)</td>
</tr>
<tr>
<td>Accidents</td>
<td>12 (7)</td>
<td>22 (14)</td>
<td>7 (10)</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>6 (3)</td>
<td>11 (7)</td>
<td>4 (6)</td>
</tr>
<tr>
<td>Complications of surgery</td>
<td>2 (1)</td>
<td>10 (6)</td>
<td>8 (12)</td>
</tr>
<tr>
<td>Neurological</td>
<td>13 (8)</td>
<td>7 (4)</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>

*Because of rounding, not all percentages total 100.

Having parents repeat what they understand is helpful so that misinformation can be corrected.
children, and the majority of both mothers (61%) and fathers (66.7%) reported that they made the decision. In addition, we found no significant difference in agreement on cause of death by race/ethnicity or parents’ participation in end-of-life decisions.

Before and after the death of an infant or a child, parents want honest, complete information delivered compassionately at a level and in language that they can understand.7 Lannen et al12 found that parents who are most likely to absorb information are parents without a history of depression, who have someone to share their problems with during the child’s illness, who are able to express their farewells to the child in the manner they want, and who feel that information is delivered in an appropriate manner. Parents have difficulties when information is provided by staff members who speak a different language or do not understand the parents’ culture.7 Parents need information repeated, often in both verbal and written form.

The discomfort that health care providers have with death and dying, especially deaths of children, is well documented.20 Some providers report feeling unprepared to deal with pain and symptom

Table 4
Concordance on cause of death: parent recall vs chart reviewa

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Yes</th>
<th>No</th>
<th>Similar</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent</td>
<td></td>
<td></td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>Mother vs chart</td>
<td>87 (54)</td>
<td>55 (34)</td>
<td>20 (12)</td>
<td></td>
</tr>
<tr>
<td>Father vs chart</td>
<td>27 (40)</td>
<td>28 (41)</td>
<td>13 (19)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>114 (50)</td>
<td>83 (36)</td>
<td>33 (14)</td>
<td></td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
<td>χ²=7.2</td>
</tr>
<tr>
<td>Mother vs chart</td>
<td></td>
<td></td>
<td></td>
<td>χ²=0.7</td>
</tr>
<tr>
<td>White non-Hispanic</td>
<td>16 (20)</td>
<td>5 (10)</td>
<td>9 (33)</td>
<td></td>
</tr>
<tr>
<td>Black non-Hispanic</td>
<td>29 (36)</td>
<td>24 (48)</td>
<td>10 (37)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>35 (44)</td>
<td>21 (42)</td>
<td>8 (30)</td>
<td></td>
</tr>
<tr>
<td>Total (n=157)</td>
<td>80 (51)</td>
<td>50 (32)</td>
<td>27 (17)</td>
<td></td>
</tr>
<tr>
<td>Father vs chart</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White non-Hispanic</td>
<td>7 (29)</td>
<td>5 (20)</td>
<td>4 (29)</td>
<td></td>
</tr>
<tr>
<td>Black non-Hispanic</td>
<td>6 (25)</td>
<td>7 (28)</td>
<td>4 (29)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>11 (46)</td>
<td>13 (52)</td>
<td>6 (43)</td>
<td></td>
</tr>
<tr>
<td>Total (n=63)</td>
<td>24 (38)</td>
<td>25 (40)</td>
<td>14 (22)</td>
<td></td>
</tr>
<tr>
<td>Unit of care</td>
<td></td>
<td></td>
<td></td>
<td>χ²=2.4</td>
</tr>
<tr>
<td>Mother vs chart</td>
<td></td>
<td></td>
<td></td>
<td>χ²=6.8b</td>
</tr>
<tr>
<td>NICU</td>
<td>34 (49)</td>
<td>26 (38)</td>
<td>9 (13)</td>
<td></td>
</tr>
<tr>
<td>PICU</td>
<td>48 (53)</td>
<td>25 (27)</td>
<td>18 (20)</td>
<td></td>
</tr>
<tr>
<td>Father vs chart</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NICU</td>
<td>10 (42)</td>
<td>13 (54)</td>
<td>1 (4)</td>
<td></td>
</tr>
<tr>
<td>PICU</td>
<td>17 (39)</td>
<td>14 (32)</td>
<td>13 (30)</td>
<td></td>
</tr>
<tr>
<td>Infant/child age group</td>
<td></td>
<td></td>
<td></td>
<td>χ²=6.2</td>
</tr>
<tr>
<td>Mother vs chart</td>
<td></td>
<td></td>
<td></td>
<td>χ²=15.7b</td>
</tr>
<tr>
<td>Infant</td>
<td>35 (36)</td>
<td>18 (18)</td>
<td>45 (46)</td>
<td></td>
</tr>
<tr>
<td>Preschool child</td>
<td>8 (29)</td>
<td>6 (21)</td>
<td>14 (50)</td>
<td></td>
</tr>
<tr>
<td>School-age child</td>
<td>5 (31)</td>
<td>1 (6)</td>
<td>10 (62)</td>
<td></td>
</tr>
<tr>
<td>Adolescent</td>
<td>3 (17)</td>
<td>2 (11)</td>
<td>13 (72)</td>
<td></td>
</tr>
<tr>
<td>Father vs chart</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant</td>
<td>20 (53)</td>
<td>5 (13)</td>
<td>13 (34)</td>
<td></td>
</tr>
<tr>
<td>Preschool child</td>
<td>3 (25)</td>
<td>6 (50)</td>
<td>3 (25)</td>
<td></td>
</tr>
<tr>
<td>School-age child</td>
<td>3 (43)</td>
<td>0 (0)</td>
<td>4 (57)</td>
<td></td>
</tr>
<tr>
<td>Adolescent</td>
<td>1 (9)</td>
<td>3 (27)</td>
<td>7 (64)</td>
<td></td>
</tr>
<tr>
<td>Length of stay, mean (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother vs chart</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In hospital</td>
<td>24.5 (37.8)</td>
<td>46.1 (79.2)</td>
<td>34.6 (53.4)</td>
<td>F=2.31</td>
</tr>
<tr>
<td>In unit</td>
<td>21.9 (33.5)</td>
<td>45.6 (79.3)</td>
<td>26.6 (42.0)</td>
<td>F=3.13b</td>
</tr>
<tr>
<td>Father vs chart</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In hospital</td>
<td>37.3 (68.3)</td>
<td>43.4 (60.2)</td>
<td>49.1 (58.9)</td>
<td>F=0.17</td>
</tr>
<tr>
<td>In unit</td>
<td>33.4 (66.9)</td>
<td>35.4 (50.6)</td>
<td>39.7 (53.0)</td>
<td>F=0.05</td>
</tr>
</tbody>
</table>

Abbreviations: NA, not applicable; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit.

a Values in second, third, and fourth columns are number (percentage), except for values for length of stay, which are mean (SD). Because of rounding, percentages may not total 100.

b P<.05.
management, and some are concerned about saving patients who “should not be saved.” Others worry about becoming too involved with patients’ families and having the ability to be objective affected, and others report feeling unsupported when caring for dying children. Years of clinical practice and training programs for health care providers can improve attitudes toward end-of-life care. These experiences also may improve comfort levels in providing such care, including ongoing communication with parents during the dying process.

Follow-up meetings with the health care team can help clarify and repeat information about the cause of death and provide opportunities for parents to have their questions answered. Because communication is a 2-way process, having parents repeat what they understand is helpful so that misinformation can be corrected or further information provided. In a study of 56 parents’ perspectives on physician-parent conferences after the PICU death of a child, Meert et al25 found that only 13% of the parents had a scheduled meeting with a physician to discuss the child’s death. However, 59% wanted to meet with their child’s intensive care physician and were willing to return to the hospital for the meeting. Among the topics parents wanted to discuss were events leading up to the death, cause of the death, autopsy findings, and what to tell the family.

Parents often feel that reviewing medical records and autopsy findings helps them understand and clarify the reasons for the child’s death. However, many parents report difficulty in knowing how to obtain autopsy findings or how to interpret the findings when they do receive them. Meetings between parents and providers can potentially reduce parents’ grief and other health risks during the long-term and reinforce that all that could be done for their child was indeed done.

In summary, many parents had misconceptions about the cause of their child’s death 1 month after the death, a finding that did not differ by race/ethnicity. Agreement was better for mothers when the deceased children’s length of stay in the ICU was the shortest. Fathers’ agreement with the chart was best when the deceased was an infant and the death was in the PICU. Talking with a physician about the infant’s or child’s prognosis, participating in decision making for end-of-life care, and being with the infant or child at the time of death did not improve agreement between parents’ reports and chart data.

Implications and Further Study

Around the time of death of an infant or child, parents’ concentration is diminished, affecting both receiving and processing of information, making ongoing communication with parents essential. Because language and cultural differences between parents and health care providers can add to this problem, having a provider, family member, friend, or advocate present from the same cultural group who speaks the same language as the parents may reduce misperceptions about cause of death. Research is needed on ways to alleviate parents’ misconceptions about cause of death. Studies on types, methods, and timing of communication with parents at the time of death of an infant or a child are needed.

ACKNOWLEDGMENT

This research was performed at Nicole Wertheim College of Nursing and Health Sciences, Florida International University.

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MEASUREMENT OF OXYGEN CONSUMPTION IN CRITICALLY ILL CHILDREN: BREATH-BY-BREATH METHOD VS MASS SPECTROMETRY

By Long Guo, MD, Yong Cui, MD, Prashant Bobhate, MD, Shine Kumar, MBBS, Shreepal Jain, MD, Mohamed Elgendi, PhD, Scott Pharis, MD, Lindsay Ryerson, MD, and Ian Adatia, MBChB

**Background** Measurement of oxygen consumption (VO$_2$) is difficult in children but is essential to calculate cardiac index and systemic vascular resistance.

**Objective** To compare measurements of VO$_2$ using respiratory mass spectrometry and the breath-by-breath method.

**Methods** VO$_2$ was measured simultaneously and continuously for 10 minutes by using respiratory mass spectrometry and the breath-by-breath method in children receiving mechanical ventilation via cuffed endotracheal tubes.

**Results** Sixteen children (7 boys; median [range]: age, 1.5 [0.2-6] years; weight, 11.5 [2.8-23.5] kg; body surface area, 0.55 [0.18-0.98] m$^2$) were studied. The correlation between measurements of VO$_2$ by the 2 methods was good ($R = 0.924$). Mean VO$_2$ measured by mass spectrometry was 63 (95% CI, 47-78) mL/min vs 65 (95% CI, 47-83) mL/min measured by the breath-by-breath method. The mean VO$_2$ difference between the 2 methods was 3 (95% CI, -9 to 5) mL/min and statistically insignificant. Bland-Altman analysis showed that the 95% limits of agreement were between -28 and + 23. Cardiac index did not differ significantly when calculated using VO$_2$ measured with one method or the other (mean difference, 0.1; 95% CI, -0.2 to 0.3).

The general consensus is that optimizing the balance between oxygen consumption ($V_O^2$) and delivery is important in managing critically ill patients.\textsuperscript{1–4} Low cardiac output syndrome adversely affects the outcomes of critically ill children on the intensive care unit.\textsuperscript{5–10} Cardiac output may be calculated by using the Fick equation if $V_O^2$, hemoglobin level, and the arterial-venous oxygen difference are known.\textsuperscript{11} However, it is difficult to measure $V_O^2$ and cardiac output, and they are rarely measured outside of research investigations, despite the suggestion that measurement of cardiac output and oxygen delivery would improve clinical outcomes of critically ill children.\textsuperscript{5–9}

Thermodilution pulmonary artery catheters are not used routinely in critically ill neonates and children. In addition, in some patients after cardiac surgery, the potential or predicted inequality between systemic and pulmonary blood flow if a cardiac shunt is present renders pulmonary artery catheters unreliable for measurement of systemic blood flow. Therefore, the most widely used research tool to measure $V_O^2$ in critically ill children, especially after cardiac surgery, has been the respiratory mass spectrometer (Amis 2000, Innovision ApS), but it is no longer manufactured.\textsuperscript{12–16} Therefore, an alternative method for measuring $V_O^2$, but the methods has not been validated in children receiving mechanical ventilation in intensive care units.\textsuperscript{17–19}

Therefore, we sought to compare the breath-by-breath (Innocor) method with mass spectrometry to measure $V_O^2$ in children receiving mechanical ventilation on the intensive care unit.

Materials and Methods

The University of Alberta’s research ethics review board approved the study. Written informed consent was obtained from the parents of all children to participate in the study.

Inclusion Criteria

Children admitted to the cardiac or medical/surgical intensive care unit who were undergoing mechanical ventilation through a cuffed endotracheal tube with indwelling central venous and arterial catheters and were considered to have sufficient hemodynamic stability for the duration of the study were included.

Exclusion Criteria

Children were excluded if there was a gas leak around the endotracheal tube, the inspired oxygen fraction ($F_O^2$) requirement was greater than 0.6, or the child displayed hemodynamic instability. The measurement of $V_O^2$ becomes inaccurate with most methods if the $F_O^2$ is greater than 0.6 because the difference between inspired and expired oxygen concentration becomes negligible.

Methods

All patients were intubated with a cuffed endotracheal tube and were receiving volume-cycled, intermittent, positive pressure, continuous flow mechanical ventilation during $V_O^2$ measurements. Systemic arterial and central venous pressures were monitored from catheters inserted to manage the patients independently of the study. Heart rate and rectal temperature were monitored continuously. Both the respiratory mass spectrometer and the Innocor were connected to the ventilator circuit. The setup and connections of the mass spectrometer, the Innocor, and the ventilator circuit are shown in Figure 1. $V_O^2$ was measured continuously and simultaneously by using mass spectrometry and the breath-by-breath method as described previously.\textsuperscript{17} Once a stable baseline was reached, $V_O^2$ was measured continuously for 10 minutes in each study participant. We calibrated both machines before each use according to the manufacturer’s instructions. All $V_O^2$ measurements were undertaken by a study investigator who was knowledgeable about and experienced with the use of both techniques.

Arterial and venous blood samples were taken from the peripheral arterial and central venous

Optimizing oxygen consumption and delivery is important in critically ill children.
The Innocor unit is based on the breath-by-breath method of gas analysis.
measured was 63 (95% CI, 47-78) mL/min by mass spectrometry and 65 (95% CI, 47-83) mL/min by the breath-by-breath method. The mean VO₂ difference between mass spectrometry and breath-by-breath groups was 3 (95% CI, -9 to 5) mL/min. Correlation between the measurements obtained with the 2 methods was good (r = 0.9). Bland-Altman analysis of VO₂ measurements (Figure 2) demonstrated that the 95% limits of agreement for VO₂ measured by the 2 methods were between -28 and 23 mL/min (mean difference, -2.4 mL/min). Both methods showed good agreement for the measured values of VO₂, with mean difference centering on zero and a tendency to clinically unimportant underestimation by the Innocor. Cardiac indexes that were calculated on the basis of the Fick equation did not differ significantly according to which method had been used to measure VO₂. The mean cardiac index calculated using VO₂ measured by mass spectrometry was 3.0 (95% CI, 2.6-3.4) and by Innocor was 3.1 (95% CI, 2.7-3.4). Bland-Altman analysis of cardiac index calculated with both VO₂ measurements showed that the 95% limits of agreement were from -0.83 to 0.75 with a mean difference of 0.04, and all the points plotted lie within the 95% CIs for the limits of agreement (Figure 3).

**Discussion**

The main findings of this study are that VO₂ measurements obtained by either respiratory mass spectrometry or the breath-by-breath method are equally accurate and that the derived cardiac indexes are comparable.

Low cardiac output syndrome adversely affects the outcomes of critically ill children in intensive care units. However, outside of research investigations, cardiac output is measured infrequently.

**Disadvantages of Thermodilution Catheter-Derived Cardiac Output in Children**

Thermodilution catheters are rarely used in neonates and small children. Balloon-tipped thermodilution catheters are difficult to float in small sick infants without fluoroscopic guidance. Thermodilution catheters may be inserted during cardiac surgery, but usually are placed only if pulmonary artery pressures need to be monitored. Thermodilution catheters do not measure systemic cardiac output in the presence of intracardiac or extracardiac shunts. They provide unreliable data if a residual shunt is present postoperatively or following surgery that includes a systemic to pulmonary shunt, for example, after the Norwood stage 1 operation.

**Advantages of Using the Fick Equation to Calculate Cardiac Output in Children**

An alternative method for calculating systemic blood flow is to use the Fick equation. The
advantages of using the Fick equation to calculate cardiac output in comparison with the technique of thermodilution are that a pulmonary artery catheter is not required and the Fick equation is more accurate than thermodilution in low cardiac output states and during high-pressure mechanical ventilation.21-23 In addition, the Fick equation can be applied in patients without a subpulmonary ventricle or with cardiac shunts.21 In patients with cardiac or extracardiac systemic to pulmonary artery shunts, the systemic venous oxygen saturation proximal to the shunt will reflect systemic cardiac output. Pulmonary artery oxygen saturation reflects pulmonary blood flow distal to the shunt. Indeed, the presence of a cardiac shunt is diagnosed through comparison of oxygen saturation in the superior vena cava with oxygen saturation in the pulmonary artery. In most circumstances, the difference is less than 3% in patients without cardiac shunts.22 Therefore, we used an oxygen saturation measured in a blood sample drawn from an internal jugular venous catheter to calculate cardiac output in our study. Most critically ill infants and children have a central venous catheter that can provide the venous oxygen saturation and hemoglobin level and either an arterial catheter or a transcutaneous oximeter to measure systemic arterial oxygen saturation. If \( V_{\dot{O}_2} \) is measured, then cardiac output can be calculated easily. The accurate measurement of \( V_{\dot{O}_2} \), together with hemodynamic data available from vascular catheters used routinely in critically ill children undergoing mechanical ventilation, permits the calculation of cardiac output, systemic oxygen delivery, and systemic vascular resistance to determine the effectiveness of therapeutic interventions. Such determinations may be particular useful in the management of children after the Norwood stage 1 procedure, when manipulation of systemic vascular resistance to determine the effectiveness of therapeutic interventions. Such determinations may be particularly useful in the management of children after the Norwood stage 1 procedure, when manipulation of systemic vascular resistance may be of value.24 However, accurate measurement of \( V_{\dot{O}_2} \) is essential to calculate cardiac output precisely using the Fick equation.23

Respiratory Mass Spectroscopy to Measure \( V_{\dot{O}_2} \)

Although respiratory mass spectrometry is accurate, it has many disadvantages in daily clinical practice because the equipment is large, takes up precious space by the bedside, has a noisy motor, high maintenance costs, and requires constant technical monitoring and specialized operator training. In addition, it performs best if left running continuously and requires a prolonged warm-up time if moved to a different location.25 The most widely used mass spectrometry machine in clinical research in critically ill children is no longer manufactured and unavailable for purchase.14-16 For these reasons, respiratory mass spectrometry is not used routinely.

The Breath-by-Breath Method of Measuring \( V_{\dot{O}_2} \)

The Innocor is portable with a quick setup time that lends itself to frequent \( V_{\dot{O}_2} \) measurements to calculate cardiac output or systemic vascular resistance in response to changes in treatment. The Innocor is a gas rebreathing unit, which is based on the breath-by-breath method of gas analysis, appears to be an accurate alternative that has the advantages of being portable, quiet, compact, and easy to use and calibrate, with economical maintenance costs.17 It has been demonstrated that the Innocor may be used with accuracy in intubated children and children receiving mechanical ventilation in the cardiac catheterization laboratory.17 The results of the current investigation suggest that the Innocor is just as effective and accurate as mass spectrometry in children on critical care units.

The drawbacks of the breath-by-breath method using the Innocor are shared with respiratory mass spectrometry and include the need for a cuffed endotracheal tube to ensure collection of all expired gas and inaccuracies with a high inspired oxygen concentration. Therefore, most methods to measure \( V_{\dot{O}_2} \) that are currently available will be of limited use in critically ill children who require a high \( F_{\dot{O}_2} \). However, the breath-by-breath method would be applicable to many critically ill children with cardiac rather than respiratory insufficiency. Prolonged, continuous measurements of \( V_{\dot{O}_2} \) are better undertaken with the respiratory mass spectrometer rather than the breath-by-breath method using the Innocor. We are cognizant that \( V_{\dot{O}_2} \) in critically ill children may vary substantially in 24 hours and that diurnal variations suggest that measurements for 30 minutes or 2 measurements separated by 15 minutes may be needed to accurately reflect \( V_{\dot{O}_2} \) and 24-hour energy expenditure in stable patients.25-27 However, we were investigating the value of \( V_{\dot{O}_2} \) to estimate systemic cardiac output at the moment of measurement rather than, for instance, estimating nutritional needs for a prolonged period. Although intermittent, repeated measurements are easily obtained using the breath-by-breath method, if continuous and prolonged measurements of \( V_{\dot{O}_2} \) are required, then alternative methods would need to be used or the Innocor method would require minor modification to prevent waterlogging of the flow meter from humidified gas. Additional potential limitations include the complexity of the respiratory circuit setup, the addition of dead space from the tubing (especially concerning in small infants with low...
and their effect on the accuracy of the VO₂ measurements. However, we continually monitored end-tidal carbon dioxide and sampled arterial blood gases and did not detect an increase in carbon dioxide. In a complex circuit, there is a potential for leaks of both the measured and inert gases.

Limitations of the Study

Limitations of this study include the relatively small number of participants. However, the numbers are sufficient to demonstrate agreement between the VO₂ measurements made with the breath-by-breath method and respiratory mass spectrometry. In addition, we were able to compare a large number of measurements by collecting data and analyzing every minute for 10 minutes in all patients, providing a total of 160 paired data points for the study. We have not explored the accuracy of the measurements in patients weighing less than 2.8 kg, and further work is required to explore the accuracy in low-birth-weight neonates.

Conclusions

This study has demonstrated that VO₂ can be measured with equal accuracy by the breath-by-breath method or mass spectrometry in intubated children undergoing mechanical ventilation who weigh more than 2.8 kg. We suggest that the breath-by-breath method may be a useful alternative method for measuring VO₂ and thus facilitating calculation of cardiac index and systemic vascular resistance routinely in children.

FINANCIAL DISCLOSURES

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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 5523); fax, (949) 362-2049; e-mail, reprints@aacn.org.
Background  Oral care plays a clear and important role in the prevention of ventilator-associated pneumonia. However, few studies have explored the actual work of oral care by nurses in the intensive care unit.

Objective  To explore intensive care nurses’ knowledge of and experiences with the delivery of oral care to reveal less visible aspects of this work.

Methods  In an institutional ethnography, go-along and semistructured interview methods were used to explore the oral care practices and perspectives of 12 bedside nurses and 12 interprofessional (intensivist, allied health, and management) participants in an intensive care unit at a large urban teaching hospital in Ontario, Canada.

Results  Nurses described how obstacles frequently inhibited the delivery of oral care. Technical barriers included oral crowding with tubes and aversive responses by patients, such as biting. Contextual impediments to oral care included time constraints, lack of training, and limited opportunities for interprofessional collaboration. A key discovery was the presence of an informal unit-based nursing curriculum, whereby nurses acquired strategies to overcome barriers to oral care. Although the nurses did extensive problem solving in providing oral care, the interprofessional participants had limited knowledge of how oral care was accomplished.

Conclusion  These data suggest the complexity of performing oral care in intensive care is underestimated and perhaps undervalued. Future research is needed to address technical and contextual barriers to optimize current guideline expectations for the provision of regular and effective oral care. (American Journal of Critical Care. 2016;25:249-256)
The accumulation of bacteria-rich oral biofilms in intensive care unit (ICU) patients who are intubated and receiving mechanical ventilation is associated with ventilator-associated pneumonia (VAP).\textsuperscript{1,2} Defined as pneumonia that occurs 48 hours or more after endotracheal intubation, VAP is estimated to occur in 9\% to 27\% of all patients treated with mechanical ventilation and is associated with an extended hospitalization and added treatment costs.\textsuperscript{3,4} To mitigate VAP, the US Centers for Disease Control and Prevention recommends a comprehensive program of oral hygiene,\textsuperscript{5} and written unit protocols are advised.\textsuperscript{6,7} Unfortunately, nurses report challenges in delivering oral care. Patient, clinician, and contextual barriers can inhibit preventive oral care.\textsuperscript{8-10} Despite expectations that effective therapies are used,\textsuperscript{11,12} no detailed accounts of nurses’ experiences and challenges in providing oral care are available.\textsuperscript{13,14}

Institutional ethnography (IE) provides a reflexive-materialist framework for thinking more purposefully about institutional practices, in this instance, oral care. Reflexively bypassing assumptions that oral care is a “basic” task, we used IE to consider how nurses negotiate the competing priorities and material conditions associated with oral care. Paying close attention to texts (paper and electronic), we examined how important oral care accountabilities are organized via documents (eg, protocols, medical orders, nursing flow sheets) and what ICU nurses know about fulfilling the responsibilities of oral care. Because prominent ways of addressing oral care may emphasize some issues (eg, VAP) and delimit others (eg, challenges of oral care) we endeavored to remain attentive to assumptions and language that might obscure important knowledge of oral care.

With a primary focus on nursing perspectives, our goal was to explore ICU nurses’ knowledge of and experiences with the delivery of oral care to reveal less visible aspects of this care.

\textbf{Methods}

In line with materialist interests of IE,\textsuperscript{15} the study began with direct clinical observation to understand the rationales and challenges of oral care from “inside” nursing experience.\textsuperscript{16} In addition to observation and interviews, work documents were collected to create an empirical bridge between oral care, interprofessional work sequences, and larger institutional expectations for patient care.

\textbf{Participants and Setting}

Study participants included bedside ICU nurses and interprofessional members (intensivists, allied health and management personnel) of the ICU team. Purposive sampling was used to achieve variation in ICU nurses’ years of experience and interprofessional roles. Participants were recruited through posters in the ICU, e-mail, and point-of-care in-service education. Fieldwork was conducted during an 18-month period (June 2011-September 2012) in a 20-bed, adult level 3 (invasive ventilatory and multiple organ system support) medical-surgical ICU at an urban academic hospital in Ontario, Canada. In accordance with recommendations\textsuperscript{17,18} to prevent VAP, care providers on the unit used an oral care protocol that included an oral chlorhexidine gluconate rinse.\textsuperscript{19-21} Hospital and university institutional review boards approved the study.

\textbf{Data Collection and Analysis}

Two levels of interviews were used. First-level processes entailed 4-hour go-along interviews with each nurse to observe and learn about oral care for intubated adults. During go-along interviews, the principal investigator (C.D.) accompanied nursing participants during patient assignments to observe, listen, and ask questions in real time. During these

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mobile sessions, nurses acted as expert navigators by explaining and providing context for oral care at the bedside.\textsuperscript{22} Within 1 month, second-level semistructured interviews with the same nurses were completed to clarify and expand on the events and documentary practices observed. Semistructured interviews with other members of the interprofessional team were conducted to better understand interprofessionals’ knowledge of and linkages to oral care provided by bedside nurses (Table 1).

Researchers’ field notes, verbatim interview transcripts, and clinical work documents were uploaded to NVivo 9 software (QRS International) for storage and organization. Preliminary analysis involved reading data passages again to identify extended sequences of work activity that connected participants across time. Instances in which nurses demonstrated or spoke concretely about oral care problems were written up and circulated to the study team.\textsuperscript{21} Then important gaps between standardized ways of speaking or documenting oral care and the unscripted problems encountered by nurses were analyzed.\textsuperscript{23} The final analysis involved identifying technical issues and contextual work-arounds to consider opportunities for innovation.

Results
A total of 12 frontline nurses (8 women and 4 men) with 1 to 30 years of clinical experience and 12 interprofessional team members (9 women and 3 men) participated. Interprofessional participants included 3 intensivists, 4 nursing management personnel, and 5 allied health professionals (respiratory therapist, physiotherapist, speech language pathologist, infection-control specialist, and hospital dentist).

The main findings were assembled into 3 spheres of nursing knowledge and activity: standardized care routines, technical barriers to oral care, and contextual work-arounds. In general, bedside nurses identified how oral care was fraught with technical and contextual barriers that had to be overcome. Whereas nurses identified the need to work around these obstacles to provide recommended VAP therapies and oral hygiene, nonnurse participants had limited knowledge of how oral care was accomplished.

Standardized Care Routines
During go-along interviews, nurses disclosed how attention to oral care was organized through standardized medical orders and documentation. Institutional expectations for VAP prevention required the addition of oral chlorhexidine to medical order forms and in preformatted nursing documentation that served as reminders to apply this antiseptic. However, nurses explained how this standardized approach obscured important facets of oral care.

<table>
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<tr>
<th>Table 1 Interview guide for the institutional ethnographic study on oral care</th>
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<td>Category</td>
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| Go-along nursing interview questions | 1. Can you tell me what you are doing (in the mouth) now?  
2. What needs to happen next?  
3. How do you know to do that?  
4. Can you show me how you document this work? |
| Semistructured nursing and interdisciplinary interview questions | 1. What are mouths like in the ICU?  
2. Can you tell me about your work related to mouth care in the ICU?  
3. Where did you learn to do this care? Tell me more about that.  
4. Can you walk me through the forms you use in practice? Where does oral care fit? |

(Note: All names inside parentheses are participant pseudonyms.) One nurse (Frank) remarked, “The chlorhexidine mouthwashes are ordered QID and . . . so then we usually do administer them at those specific times. But that doesn’t mean that mouth care only happens at those times. It’s just the chlorhexidine washes or rinses that happen at that time.”

This quote is illustrative of several nurses’ concerns that actual oral care (ie, care beyond the application of chlorhexidine) was not fully disclosed in the patient care record. For example, nurses demonstrated oral care requirements in addition to VAP. These needs included dry mouth, thirst, hypersalivation, pressure ulcers, and “neurobreath” (halitosis associated with neurological illness). Nurses explained that addressing and communicating these issues were important to patients’ comfort and dignity, in addition to prevention of infection. However, preset documentation fields for these issues were not provided in standardized charting accessed by all members of the ICU interprofessional team.

Despite the increased time nurses spent in narrative charting to document an array of oral problems and interventions, intensivists and allied health team members reported insufficient time to review narrative nursing notes. One intensivist (John) commented, “The narrative component of care is clearly really important. [But] it’s just hard for people to kind of pick out the details that are important, and I think a lot of the docs probably don’t ever look at the narrative part of the flow sheet.”

Whereas all interprofessional participants noted that oral care had a clear and important role in

Bedside nurses identified how oral care was fraught with technical and contextual barriers.
Nurses emphasized strategies and efficiencies that highlighted a commitment to oral care. Safeguarding patients from adverse outcomes, these participants had limited awareness of how and when nurses provided this care. In contrast, nurses identified explicit strategies for the accomplishment of oral care in the unpredictable ICU. As one nurse (Bill) noted, “When you do your assessment, say your neuro exam, you have to check for a gag. And you have to report a cough. So, I suction and I do mouth care. That’s one of the things that I do. I kind of intertwine it in my assessment.”

Another nurse (Nicky) added, “When I reposi-tion a patient, which we do every 2 hours, I’m usually assessing their oral care anyway because sometimes, as you turn them, you know they created secretions. So you’re having to do some sort of oral care at that point.”

In describing the incorporation of oral care across different domains of practice, nurses emphasized strategies and efficiencies that highlighted a commitment to oral care (Table 2).

Ongoing appraisal of a patient’s mouth by bedside nurses was included with the expectations for surveillance, triage, and medical diagnostics. For example, a patient’s ability to follow commands could be assessed by asking the patient to open the mouth, which could then be inspected. Similarly, coughing and gagging during oral care provided information on airway reflexes that allowed for assessment of aspiration risk and secretion management. A nurse (Pat) noted, “It’s important to keep the patient clean, it’s less risk for infection and um, sometimes you can visualize, the more you can visualize things in a neat and tidy way, the easier it is to pick up on something that’s abnormal.”

In addition to being facets of oral care, nursing activities involving the oral space produced essential clinical data, which informed medical diagnosis and care planning. Therein, nurses elucidated the complexity and importance of oral care to the patient and the interdisciplinary team. However, documentary analysis revealed limitations in the way oral care could be readily recorded and described, thus concealing the full scope of practices and benefits attributed to oral care.

### Technical Barriers

While demonstrating oral care, nurses revealed how oral tubes and securement devices often acted as physical barriers to access to the mouth, increasing both the technical difficulty and the time required for care. Devices in the mouth often impaired visual assessment and limited access for oral care tools. In extreme instances, oral care was described as next to impossible. One nurse (Frank) remarked, “A lot of time you’re almost going [in] blind when you’re doing mouth care. The sicker patients, I think they become very difficult to do because not only do you have an ETT but you’ll have an OG [orogastric tube], you’ll have an oral temperature probe in there. So, you get limited space inside there. So, I think from that standpoint it gets really hard.”

During their attempts to enter the mouth with oral suctioning tubes, toothbrushes, and sponge swabs, nurses described how patients could resist oral interventions, further exacerbating procedural difficulty. One participating nurse (Sally) said, “He definitely was doing a lot of biting down on the tube, and so it was hard even to get access to his mouth. So, that’s definitely a barrier for a lot of nurses. If you can’t get into the mouth, then how are you to perform mouth care?”

Whereas some nonnurse participants were uncertain about patients’ responses to hygiene, nurses clarified that patients can experience oral care as discomforting and even painful (Table 3). One nurse (Lucy) drew upon her collective
experience to explain patients’ aversive responses: “I think for some patients it’s probably like a primitive reflex. I think for other patients it’s a discomfort thing and they just don’t like anybody in there. There might be some pain associated with, you know, rubbing the tongue, brushing the teeth, even going, even entering it at all. And, there’s just a lot of sensitivity in the mucosal area. And so, they really absolutely cringe when you even go in to touch their mouth.”

Oral interventions elicited certain patients to “bite,” “thrash about,” or “pull at the tube,” making self-extubation a possibility. These behaviors generated additional technical barriers and sometimes required the interruption or termination of oral care.

### Contextual Work-arounds

Limitations in nurses’ control over their time in the unpredictable ICU made it expedient to incorporate oral care into other routines as described earlier. However, nurse participants identified how this strategy was vulnerable to patient acuity. One nurse (Aly) explained, “If you have a really, really busy patient who’s really, really sick and um, you’re having hard times managing their blood pressure or their ventilation or there’s just one thing after another happening, mouth care kind of slides to the bottom of the list.”

Nurses emphasized the importance of proficiency and speed in navigating the needs of any patient whose clinical status was unstable. However, they also reported limited opportunities to acquire efficient and effective oral care skills within formal educational curricula. Lack of academic preparation in oral care delivery made it especially important for new nurses to spend time learning the “tricks of the trade” from senior nurses. As one nurse (Lucy) put it, “I have not really been, you know, taught it formally, you know, in a classroom or anything like that. But just at the bedside observing other nurses, . . . I definitely learned from experienced staff.”

Use of an informal unit-based nursing curriculum overcame this knowledge gap by transmitting essential oral care skills, including advanced patient communication strategies. For example, lip reading was taught to facilitate nurse-patient communication and cooperation during oral care activity. One nurse (Bill) said, “I try to talk them through it; explain what’s happening. You know, give them a timeline of how long is this going to be. ‘Okay, one more second.’ So that they understand, it’s not going to be forever. . . . I read their lips to understand what they need.” Another nurse (Nicky) said, “I had a patient who had his jaws wired. . . . I just had to negotiate with him so that we could get in there.”

Additional strategies included in the informal curriculum to overcome technical and time-related barriers to mouth care were having 2 people provide oral care; inserting bite-blocking devices; cleaning during repositioning of endotracheal tubes, and

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**Table 3  
Technical barriers to oral care**

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Nursing examplea</th>
<th>Interdisciplinary examplea</th>
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<tr>
<td>Limited oral access</td>
<td>Sometimes you barely can stick the Yankauer inside the patient’s mouth, just for basic oral suction. Technically . . . it’s a very difficult thing. (Bob, RN)</td>
<td>Sometimes you can’t get to the mouth as much, right, because the Yankauers are pretty big. (Michelle, RT)</td>
</tr>
<tr>
<td>Aversive responses of patient</td>
<td>When you have to do mouth care and the patient may be biting on their tube, they don’t want anything foreign introduced into their mouth for fear or a natural reflex. So, um, in the ICU it, it becomes a little bit more complicated. (Bill, RN)</td>
<td>Well around intubation time [patient cooperation is] less of an issue because most of our patients are sedated if not anesthetized and paralyzed. (Danielle, intensivist)</td>
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<td></td>
<td>You can tell by their facial expression that [the oral chlorhexidine gluconate] is stinging or the taste just isn’t right or it’s burning a little bit. (Nicky, RN)</td>
<td>I guess sometimes it is a bit uncomfortable? (John, intensivist)</td>
</tr>
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<td></td>
<td>I think the actual swab in their mouth is not comfortable when you do mouth care. Just even washing the back of, the roof of their mouth; you know it could make them gag. (Sally, RN)</td>
<td>In specialized dental practices, there’s 2 approaches. One is the human approach in which you try to get cooperation and trust, and, you know, the other is the pharmacological approach: sedate them. (Mary, hospital dentist)</td>
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</table>

Abbreviation: ICU, intensive care unit; RN, registered nurse; RT, respiratory therapist.

a Names in parentheses after quotes are participant pseudonyms.

b Oral suctioning device.
using on-the-spot innovation to modify tools for oral access and comfort.

Despite these complex problem-solving activities, intensivists and unit leaders reported limited awareness of oral care problems or related nursing activities. An intensivist (Danielle) remarked, “I don’t know what [oral care] the nurses do on a regular . . . on a routine basis.” An ICU administrator (Carrie) commented, “I would hope, and gee I haven’t asked the question, that they are teaching [mouth care] in the critical care curriculum.”

In reflecting on these knowledge gaps, all participants identified insufficient time for team-based collaboration in preventive oral care. Because of this lack of time, opportunities to discuss oral health problems in relation to other care priorities were limited. Thus, widespread interprofessional recognition of oral care as a complex nursing practice was limited.

**Discussion**

Our results have improved our understanding of ICU nurses’ knowledge of and experience with delivery of preventive oral care by revealing the less visible aspects of this care. Nurses’ ability to anticipate and resolve hygiene barriers are critically important; increasing numbers of patients worldwide require acute and prolonged mechanical ventilation.24-27 A comparison of our data with published oral care guidelines and clinical documentation indicated that the complexity of preventive oral care is taken for granted. Key findings include frequent barriers to oral care, including oral crowding and aversive responses,28 and nursing work-arounds to meet these challenges.29 In allowing nurses to reveal hitherto nonvisible aspects of oral care, we discovered a disconnect between guideline recommendations and the problems nurses encounter.

Although oral care guidelines recommend standardized practices,3 oral data suggest that the guidelines do not acknowledge important nursing challenges, including methods to overcome barriers to oral access.30 ICU physician orders and flow sheets may similarly not include the practical aspects of oral care, thereby perpetuating assumptions that oral care is a basic task. Other research31 has indicated that nurses often accomplish more than clinical records reveal, and so the realities of nursing work are not apparent. Likewise, we have distinguished limits to the fidelity of clinical documentation that most likely are due to time pressures and the shortcomings of existing documentation.32 Although nurses are accountable to provide both oral care and ongoing clinical documentation, standardized records may obscure actual events.

The nurse participants in this study were concerned about patients’ discomfort during oral care. This finding aligns with the results of other research, indicating that routine ICU activities (eg, repositioning and suctioning) are a source of patients’ distress33-35 and that corresponding assessment and management of pain, agitation, and delirium are needed.36 Although patients’ discomfort during oral procedures has been examined in other populations of patients,37-39 this issue in ICU patients has received limited attention.31,40 Our findings suggest this gap in procedural knowledge may have serious implications for the effective application of oral chlorhexidine and selective oral decontamination with antibiotic pastes to prevent VAP.28

**Implications for Practice**

We found that key ICU personnel such as intensivists and unit leaders had limited knowledge of the difficulties nurses experienced and the extensive work-arounds used in oral care. Although teamwork and effective communication are essential for safe patient care,41 our data suggest important dimensions of oral care, such as the time and skill required, go unrecognized by ICU team members. This finding negates recommendations for enhanced patient safety through interprofessional communication and collaboration.42,43 Limited opportunities to discuss oral problems and the prevention of these problems may constrain efforts to enhance the quality and safety of patient care.

On the basis of our findings, we recommend that nurses consider critical social theories of textual organization whereby clinical documentary practices are understood to make certain elements of nursing visible whereas other elements are taken for granted.30,44,45 Therefore, standardized documentation of oral care could be amended to include the behavioral and technical components of this care. In line with recommendations of previous studies46-49 that reported limited procedural preparation for oral care, professional development could include formal instruction in methods to mitigate limited oral access, such as advanced patient communication skills,50 and work-arounds that include modification of tools or procedures.51,52 To further enrich the evidence base for application of oral care, ICU researchers could investigate prevalence and predictors of barriers to oral care, oral pain, theories of aversive oral behaviors, and patients’ recollections.

Strengths of our study include use of rigorous data collection methods to address a key, difficult-to-study aspect of oral care. By using multiple forms of data collection, we addressed some of
the contextual limitations of surveys, which have been the primary method of investigating nurses’ knowledge and practices of oral health to date. Furthermore, we included diverse ICU personnel. Nevertheless, our study has limitations. Data were collected in a single academic ICU, a step that limits insights relevant to other populations of patients and care settings. The presence of the researcher in go-along interviews may have influenced the sequence of care and the events observed. Finally, the design of the study excluded the perspectives of patients and patients’ family member, data that might have offered important insights.

Conclusion

Oral care conducted in the ICU by bedside nurses remains fraught with challenges. Our results provide new insights to technical and contextual barriers and suggest that the complexity of performing oral care in the ICU is underestimated and perhaps undervalued. Effective management of oral care barriers is not addressed in current practice guidelines and may affect optimal delivery of VAP-preventive strategies such as application of topical oral chlorhexidine and selective oral decontamination. Further inquiry is required to better understand barriers to oral care and possible solutions to those problems.

FINANCIAL DISCLOSURES

This study was funded by a Canadian Institutes of Health Research, Frederick Banting and Charles Best Canada Graduate Scholarship Doctoral Award.

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REFERENCES

1. Identify the potential barriers to oral care delivery for intubated intensive care unit patients.
2. Discuss the implications to practice as a result of this study.
3. Identify additional research needed to expand the evidence base for oral care delivery.

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Noninvasive Monitoring of Cardiac Output During Weaning From Mechanical Ventilation: A Pilot Study

By Maged Tanios, MD, MPH, Scott Epstein, MD, Sharon Sauser, RCP, RRT, and Amy Chi, MD

Background Cardiac dysfunction is one of many causes for unsuccessful weaning from mechanical ventilation. Although cardiac dysfunction can be detected via direct measurement of cardiac output during weaning, available methods are not feasible.

Objective To investigate the role of noninvasive monitoring of cardiac output during weaning and determine if a relationship exists between serial measurements during the spontaneous breathing trial and weaning outcomes.

Methods A prospective, observational study was conducted in the intensive care unit at a university-affiliated teaching hospital. The sample consisted of patients intubated for more than 24 hours who were being weaned off of mechanical ventilation according to a validated weaning protocol. Before the first spontaneous breathing trial, a noninvasive cardiac output monitor was connected to the ventilator circuit. Measurements were made before, at the beginning of, and at the end of the trial.

Results Among the 85 patients tested, baseline cardiac output was similar (P = .93) for those in whom the first trial was successful (mean [SD], 5.7 [2.1] L/min) and those in whom the trial was unsuccessful (5.6 [1.8] L/min). Unlike patients with unsuccessful trials, patients with successful trials were able to augment their cardiac output from baseline. Mean cardiac output increased to 7.1 (SD, 3.1) L/min for patients in whom weaning was successful and to 6.2 (SD, 2.3) L/min for those in whom weaning was unsuccessful (P = .001).

Conclusion A noninvasive method of monitoring cardiac output can be easily applied while patients are being weaned off of mechanical ventilation. (American Journal of Critical Care. 2016;25:257-265)
Mechanical ventilation is an essential lifesaving intervention for patients who experience respiratory failure while recovering from a critical illness. Once they recover from the acute illness, weaning from mechanical ventilation is started. The main cause of acute respiratory failure is usually detected and promptly treated, but patients may have comorbid conditions that are manifested later, during the weaning phase. Among these conditions are myocardial ischemia and congestive heart failure.1

The decrease in ventilator support during a spontaneous breathing trial (SBT) can increase preload, afterload, and catecholamine release2-5 and possibly exacerbate underlying cardiac dysfunction, resulting in pulmonary edema and unsuccessful weaning. These processes may also cause myocardial ischemia,6 leading to pulmonary edema related to the increased transmural pulmonary artery occlusion pressure associated with decreased myocardial compliance. Indeed, myocardial ischemia can occur during weaning.2-7 Therefore, myocardial ischemia should be considered as an important cause of unsuccessful weaning. In patients with obstructive lung disease, unsuccessful weaning may be associated with worsening dynamic hyperinflation, which may also result in cardiac dysfunction. Early recognition of the causes of unsuccessful weaning may prompt early directed interventions, especially if a reversible cause such as myocardial ischemia or fluid overload is detected. The aim of our study was to evaluate the role of noninvasive monitoring of cardiac output during weaning and to determine if a relationship exists between serial measurements during the SBT and weaning outcomes.

Methods

The study was approved by the appropriate institutional review board. Because of the strict observational nature of the study and the use of already present noninvestigational commercially available equipment, need for informed consent was waived by the board.

Sample

A convenience sample of 85 consecutive adult patients were enrolled in the study during the period November 2008 through May 2010. All adult patients admitted to an intensive care unit (ICU) at St Mary Medical Center, Long Beach, California, a teaching hospital, who had respiratory failure that required invasive mechanical ventilation for a minimum of 24 hours were eligible. All patients judged ready for weaning by their primary treating physician were considered for enrollment. Exclusion criteria for enrollment were age 18 years or younger, an expected survival of less than 48 hours, primary neurological event without expectation for recovery, or already undergoing weaning trials. Each patient was allowed to be enrolled only once. Research coordinators who were not involved in the patients’ routine care screened and enrolled eligible patients in the study.

Study Design

The study was a prospective descriptive analysis of patients treated with mechanical ventilation who were intubated for more than 24 hours at the onset of the preparation for weaning. Treating physicians determined the ventilator settings, and weaning was performed according to an institutionally approved weaning protocol. When participants met preset criteria for weaning, an SBT was attempted, and treating physicians were notified of the outcome of the trial. If the trial was successful, participants were extubated at the request of the treating physician. The study was observational, did not include any intervention, and cardiac output values were available to treating physicians.

About the Authors

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only on request. The analyses were conducted for the first SBT for each participant.

Weaning Protocol. All participants were weaned according to a validated10 weaning protocol. Respiratory care practitioners conducted screenings every morning to assess readiness for weaning. Five criteria had to be satisfied to pass the daily screening: (1) ratio of $P_{aO_2}$ to fraction of inspired oxygen ($F_{iO_2}$) greater than 150 or greater or oxygen saturation as measured by pulse oximetry greater than 90% at $F_{iO_2}$ of 0.4 or less, (2) positive end-expiratory pressure 5 cm H$_2$O or less, (3) mean arterial pressure 60 mm Hg or greater without vasopressor agents, (4) awake or easily arousable, and (5) adequate coughing during suctioning and not requiring suctioning more often than every 2 hours. Participants who met the daily screening criteria automatically had a 2-hour SBT performed with 5 cm H$_2$O of continuous positive airway pressure and 6 cm H$_2$O of pressure support. Participants were monitored for the first 5 minutes and then every 15 minutes during weaning. If a participant did not meet the daily screening criteria, no SBT was conducted, and the managing physician was notified by the respiratory therapist of the findings.

Weaning was considered unsuccessful if any of the following occurred: diaphoresis, agitation, or dyspnea; signs of increased work of breathing for more than 15 minutes; hypoxemia ($P_{aO_2}$<60 mm Hg or arterial oxygen saturation<90%); increased respirations to more than 35/min for more than 5 minutes; tachycardia (heart rate > 140/min), or bradycardia (heart rate <50/min), or a sustained 20% change in either direction; systolic blood pressure more than 180 mm Hg or less than 90 mm Hg; hypercapnia ($P_{aCO_2}$ increased by > 10 mm Hg from the value before weaning, order for arterial blood gas analysis by treating physicians).

Participants with successful SBTs were evaluated for extubation. Participants were considered for extubation if they required suctioning at intervals of more than 2 hours, were arousable, and had a cough, and no procedures (eg, bronchoscopy) were planned that would hinder or delay extubation. If a participant had a successful SBT and met extubation criteria, a respiratory care practitioner consulted with the managing physician to obtain an order to extubate. Participants with unsuccessful SBTs were permitted to have a repeat SBT at the discretion of the managing physician. Patients continued to be screened daily until extubation, 21 days after enrollment, performance of tracheostomy, death, or withdrawal of care.

Cardiac Output Monitoring. Cardiac output was measured by connecting the NICO Cardiopulmonary Management System (Philips, LLC) to the ventilator circuit before the SBT was started.11,12 The NICO system is a commercially available noninvasive monitoring device that calculates cardiac output by measuring changes in the respiratory concentration of carbon dioxide caused by brief periods of rebreathing. The exhaled carbon dioxide ($P_{eco_2}$) values are obtained by attaching the flow sensor of the NICO system to the swivel connector in line with the endotracheal tube. With this method, exhaled carbon dioxide is measured by an infrared spectrometer attached to the ventilator circuit. A partial carbon dioxide rebreathing technique, with a 150-mL dead-space circuit, is used to calculate cardiac output by measuring the difference between exhaled carbon dioxide ($P_{eco_2}$) during a 35-second rebreathing period, in comparison with the normal ventilation period.11,13 Cardiac output is determined by calculating the carbon dioxide production ($V_{CO_2}$) on a breath-by-breath basis and applying a differential Fick equation to establish the relationship between $V_{CO_2}$ and cardiac output according to the equation $V_{CO_2}=cardiac output×(Cv–CaCO_2)–(S×ΔP_{ETO_2})$, where $Cv$ is the carbon dioxide content in mixed venous blood, and $CaCO_2$ is the carbon dioxide content in arterial blood. Then cardiac output in the equation is replaced by $ΔV_{CO_2}/(S×ΔP_{ETO_2})$, where $ΔV_{CO_2}$ is the change in $V_{CO_2}$ and $ΔP_{ETO_2}$ is the change in end-tidal carbon dioxide ($P_{ETO_2}$) between normal breathing and carbon dioxide rebreathing, and S is the slope of the carbon dioxide dissociation curve from hemoglobin.

In order to further validate data on cardiac output, pulmonary capillary blood flow (PCBF) was measured, and the results were analyzed. Similarly, PCBF (in milliliters per minute) was measured by using partial carbon dioxide rebreathing and corresponds to the difference between nonrebreathing and rebreathing periods: $ΔV_{CO_2}/(S×ΔP_{ETO_2})$, where S is the slope of the carbon dioxide dissociation curve from hemoglobin.14 When available, data were collected on the presence of systolic or diastolic dysfunction, and the presence of moderate or severe valvular disease from echocardiograms that were obtained for routine care during the current admission, and the concentration of B-type natriuretic peptide (BNP) was measured within 24 hours before the weaning trial.

Sedation Protocol. All participants were sedated according to an institutionally approved sedation protocol.15 Participants who had stable hemodynamic
status or were anticipated to require mechanical ventilation for less than 72 hours were given a continuous infusion of propofol starting at 5 to 10 μg/kg per minute up to a maximum dose of 50 μg/kg per minute. Participants who had unstable hemodynamic status or were anticipated to require mechanical ventilation for more than 72 hours were given a continuous infusion of midazolam starting at 0.02 mg/kg per hour up to a maximum dose of 1 mg/kg per hour. Both groups received a continuous infusion of fentanyl starting at 0.5 μg/kg per hour up to a maximum dose of 10 μg/kg per hour. The goal of sedation was discussed on daily multidisciplinary rounds, and the level was monitored by using the Richmond Agitation–Sedation Scale. Interruption of sedation was performed daily at 9 AM for neurological assessment, and sedatives were restarted at 50% of the original dose and then titrated to the desired score on the scale. Participants in the following categories were excluded from the interruption of sedation: concurrent use of paralytic agents, open chest after cardiac surgery, or the presence of intracranial hypertension.

**Study Outcome and Variables**

The primary outcome for the study was the result of the first SBT in relation to cardiac output and PCBF during weaning from mechanical ventilation and to weaning time. The weaning time was defined as the duration of mechanical ventilation from the first daily screening until a study end point was reached (extubation 21 days after enrollment). The reintubation rate for unsuccessful extubation was defined as the need for reintubation within 72 hours after extubation. Other variables included were the ICU length of stay and hospital length of stay.

A laptop computer was connected to the communication port of the NICO output monitor, and data were recorded and stored for analysis by using respiratory profile analysis software (FlowTool Viewer for Windows, for use with NICO system). For the purpose of the study, respiratory parameters were measured at baseline before the weaning trial started, 5 minutes into the SBT, and then every 30 minutes during the 2-hour SBT and/or at the conclusion of the SBT. The measurement points for cardiac output and PCBF included in the analyses were baseline, 5 minutes after the SBT started, 30 minutes after the SBT started, and/or at the conclusion of the SBT. Data collection ceased once the participant reached 1 of the following study end points: successfully extubated, deemed difficult to wean, underwent a tracheostomy procedure, reached 21 days after the onset of the first weaning attempt, transferred to another service, or died. The medical records of participants were reviewed to obtain patients’ demographics, causes of admission and respiratory failure, duration of respiratory failure (dates of intubation and extubation), dates of discharge from the ICU and the hospital, and hospital outcomes.

**Statistical Analysis**

A 2-sided test with a type I error rate of 0.05 was used for analysis of data. The distribution of differences in the participants’ characteristics between weaning groups (successful or unsuccessful SBT) was determined by using χ² analysis for categorical variables; an independent 2-sample t test for continuous, normally distributed variables; and the nonparametric Mann-Whitney rank-sum test for continuous variables that had departures from normality. Significance of within participant changes in mean cardiac output and PCBF at the end of the SBT compared with baseline values were assessed by using a paired t test. Multivariable logistic regression analysis was used to examine whether increased percent change in cardiac output increased the likelihood of weaning (successful or unsuccessful first SBT) after adjustment for potential confounding factors. Percent change in cardiac output was also used as a test variable for constructing a receiver operating characteristic curve; weaning outcome was specified as the state variable. Analyses were performed by using SPSS Statistics for Windows, version 21.0, software (IBM Corp).

**Results**

A total of 85 participants were included in the study (Table 1). The mean age was 64 years (SD, 17), and 48% were male. The baseline APACHE II score was 22 (SD, 7). The majority of participants were white (54%). Sepsis was the most common cause of respiratory failure (32%); next most common were severe (or complex) pneumonia (13%) and acute respiratory distress syndrome (12%). The 2 major comorbid conditions noted in the medical records were congestive heart failure (27%) and chronic obstructive pulmonary disease (20%). Most participants were intubated on the day of

Participants whose first spontaneous breathing trial was successful were able to augment their cardiac output from baseline.
admission (mean, day 0; interquartile range [IQR], 0-4), and weaning was started a mean of 5.6 (SD, 4.4) days from initiation of mechanical ventilation.

A total of 66% of the participants were successful in their first weaning attempt (ie, first SBT); of these, 6% required reintubation. Although participants whose SBT was unsuccessful had a higher reintubation rate (11%), the difference between the 2 groups was not significant ($P = .68$). The median duration for ICU length of stay was 9 (IQR, 6-14) days, and the median hospital length of stay was 15 (IQR, 10-33) days.

Table 2 shows that participants whose first SBT was successful did not differ from participants whose first SBT was unsuccessful: mean age 62 (SD, 19) years vs 68 (SD, 12) years ($P = .14$); male sex 54% vs 38% ($P = .17$); or mean APACHE II score 22 (SD, 7) vs 22 (SD, 6) ($P = .90$). The 2 groups had equivalent oxygenation and ventilation parameters according to arterial blood gas analysis and comparable levels of BNP measured within 24 hours before the start of the weaning trials.

Echocardiographic results were available for 23 of the 56 patients (41%) whose SBTs were successful and for 27 of the 29 patients (93%) whose SBTs were unsuccessful. The mean dead space to tidal volume ratio ($V_{D}/V_{T}$ ratio) was similarly high in both groups: 0.49 (SD, 0.08) vs 0.53 (SD, 0.10) ($P = .10$). Baseline cardiac output did not differ between participants with successful SBTs and those with unsuccessful SBTs ($P = .93$). Participants whose SBTs were successful augmented their cardiac output from a mean baseline value of 5.8 L/min (SD, 2.2) to a mean of 7.1 L/min (SD, 3.1); $P < .001$, whereas participants whose trials were unsuccessful augmented their cardiac output from a mean baseline value of 5.7 L/min (SD, 1.8) to a mean of 6.2 L/min (SD, 2.3); $P = .09$.

Participants whose first SBT was successful were able to augment their cardiac output from baseline; participants whose first SBT was unsuccessful did not have the same response ($P = .001$; see Figure). A similar pattern was noted in the PCBF response. Participants whose first SBT was successful were able to augment their cardiac output by a mean of 25.6% (SD, 35.5%), whereas participants whose first SBT was unsuccessful were able to augment their cardiac output by a mean of 9.1% (SD, 24.7%) ($P = .03$). When results were analyzed by using multivariate regression including age, sex, diagnostic category, and APACHE II score on admission, the percentage change in cardiac output was an independent predictor for weaning outcome ($P = .045$). The receiver operating characteristic curve for 10% change in cardiac output and weaning outcome showed an area under the curve of 0.63. In addition to their ability to augment cardiac output, patients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>64 (17)</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>48</td>
</tr>
<tr>
<td>APACHE II score, a mean (SD)</td>
<td>22 (7)</td>
</tr>
<tr>
<td>Race, %</td>
<td>White 54</td>
</tr>
<tr>
<td>Primary reasons for respiratory failure, %</td>
<td>Sepsis 32</td>
</tr>
<tr>
<td>Primary admission category, %</td>
<td>Pulmonary disorder 35</td>
</tr>
<tr>
<td>Major medical history, %</td>
<td>Congestive heart failure 27</td>
</tr>
<tr>
<td>Arterial blood gas analysis, mean (SD)</td>
<td>pH 7.45 (0.05)</td>
</tr>
<tr>
<td>Brain natriuretic peptide, d mean (SD), pg/mL</td>
<td>696 (781)</td>
</tr>
<tr>
<td>Days before intubation, median (interquartile range)</td>
<td>0 (0-4)</td>
</tr>
<tr>
<td>Days of mechanical ventilation before weaning a</td>
<td>Mean (SD) 5.6 (4.4)</td>
</tr>
<tr>
<td>Outcome of first weaning, % with successful first spontaneous breathing trial</td>
<td>66</td>
</tr>
<tr>
<td>Total days of mechanical ventilation, mean (SD)</td>
<td>6.5 (4.4)</td>
</tr>
<tr>
<td>Days in intensive care unit</td>
<td>Mean (SD) 9.0 (8.2)</td>
</tr>
<tr>
<td>Days in hospital</td>
<td>Mean (SD) 31 (49)</td>
</tr>
</tbody>
</table>

a Baseline score on Acute Physiology and Chronic Health Evaluation II, an assessment of the severity of illness, with scores ranging from 0 to 71.

b Includes history of coronary artery bypass graft surgery.

c Liver cirrhosis, uncontrolled diabetes mellitus, uncontrolled hypertension, end-stage renal disease on hemodialysis, neuromuscular disorders, and various other diagnoses.

d Days were available within preceding 24 hours before the first spontaneous breathing trial for 37 patients.

a Days from intubation to first spontaneous breathing trial.
whose first SBT was successful had a shorter weaning time than did participants whose first SBT was unsuccessful (mean, 1.14 [SD, 2.9] days vs 2.9 [SD, 2.5] days; P = .01), shorter total mean duration of mechanical ventilation (5.8 [SD, 3.9] days vs 9.3 [SD, 5.6] days; P = .05), and lower median ICU length of stay (7 [IQR, 5-11] days vs 16 [IQR, 7-27] days; P = .01) (Table 2). The 2 groups did not differ in mean duration of treatment with mechanical ventilation before weaning (4.8 [SD, 2.8] days vs 7.5 [SD, 6.6] days; P = .17); however, the group whose first SBT was successful tended to have a lower median total hospital length of stay: 13 (IQR, 10-25) days vs 31 (IQR, 15-54) days; P = .05.

### Table 2

Outcomes of weaning trials for 85 patients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>First spontaneous breathing trial</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Successful</td>
<td>Unsuccessful</td>
<td></td>
</tr>
<tr>
<td>No. (%) of patients</td>
<td>56 (66)</td>
<td>29 (34)</td>
<td></td>
</tr>
<tr>
<td>Age, mean (SD), years</td>
<td>62 (19)</td>
<td>68 (12)</td>
<td>.14</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>54</td>
<td>38</td>
<td>.17</td>
</tr>
<tr>
<td>APACHE II score, mean (SD)</td>
<td>22.6 (7.9)</td>
<td>22.4 (6.0)</td>
<td>.90</td>
</tr>
<tr>
<td>Arterial blood gas analysis, ( a ) mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.44 (0.05)</td>
<td>7.46 (0.05)</td>
<td>.15</td>
</tr>
<tr>
<td>( Pao_2 ), mm Hg</td>
<td>101 (28)</td>
<td>95 (27)</td>
<td>.35</td>
</tr>
<tr>
<td>( Pao_2 ); fraction of inspired oxygen</td>
<td>253 (71)</td>
<td>238 (68)</td>
<td>.18</td>
</tr>
<tr>
<td>( Paco_2 ), mm Hg</td>
<td>38 (8)</td>
<td>37 (8)</td>
<td>.80</td>
</tr>
<tr>
<td>Brain natriuretic peptide, ( b ) mean (SD), pg/mL</td>
<td>557 (768)</td>
<td>878 (784)</td>
<td>.22</td>
</tr>
<tr>
<td>Echocardiography, ( c ) No. of patients</td>
<td>23</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Normal findings</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Systolic dysfunction</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Diastolic dysfunction</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Pulmonary hypertension</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Wall motion abnormality</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Valvular heart disease</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>( V_o:V_t ) ratio, mean (SD)</td>
<td>0.49 (0.08)</td>
<td>0.53 (0.10)</td>
<td>.10</td>
</tr>
<tr>
<td>Cardiac output before SBT, mean (SD), L/min</td>
<td>5.7 (2.1)</td>
<td>5.6 (1.8)</td>
<td>.93</td>
</tr>
<tr>
<td>PCBF before SBT, mean (SD), L/min</td>
<td>5.1 (1.8)</td>
<td>4.8 (1.5)</td>
<td>.47</td>
</tr>
<tr>
<td>Change in cardiac output, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>25.6 (35.5)</td>
<td>9.1 (24.7)</td>
<td>.03</td>
</tr>
<tr>
<td>Median (interquartile range)</td>
<td>17.9 (1-28)</td>
<td>7.8 (3-26)</td>
<td></td>
</tr>
<tr>
<td>Days of mechanical ventilation before weaning ( d )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>4.8 (2.8)</td>
<td>7.5 (6.6)</td>
<td>.17</td>
</tr>
<tr>
<td>Median (interquartile range)</td>
<td>4 (3-7)</td>
<td>5.5 (2-11)</td>
<td></td>
</tr>
<tr>
<td>Weaning time, days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>1.14 (2.9)</td>
<td>2.9 (2.5)</td>
<td>.01</td>
</tr>
<tr>
<td>Median (interquartile range)</td>
<td>0.00 (0-0.7)</td>
<td>3 (0.5-5.5)</td>
<td></td>
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<tr>
<td>Total days of mechanical ventilation</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Mean (SD)</td>
<td>5.8 (3.9)</td>
<td>9.3 (5.6)</td>
<td>.05</td>
</tr>
<tr>
<td>Median (interquartile range)</td>
<td>4.5 (3-8)</td>
<td>7 (5-15)</td>
<td></td>
</tr>
<tr>
<td>Days in intensive care unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>9.4 (7.2)</td>
<td>16.5 (9.1)</td>
<td>.01</td>
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<tr>
<td>Median (interquartile range)</td>
<td>7 (5-11)</td>
<td>16 (7-27)</td>
<td></td>
</tr>
<tr>
<td>Days in hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>29.6 (54)</td>
<td>38.4 (31.6)</td>
<td>.05</td>
</tr>
<tr>
<td>Median (interquartile range)</td>
<td>13 (10-25)</td>
<td>31 (15-54)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; PCBF, pulmonary capillary blood flow; SBT, spontaneous breathing trial; \( V_o \), dead space ventilation; \( V_t \), tidal volume.

\( a \) Performed before initiating the SBT.

\( b \) Values were available within 24 hours before the first SBT for 21 patients whose trial was successful and for 16 patients whose trial was unsuccessful.

\( c \) Results of echocardiography available before weaning obtained as part of routine care; only the primary finding was listed for each study.

\( d \) Days from intubation to first SBT.
Discussion

The results of our pilot study indicate that participants whose first SBT was unsuccessful were unable to augment cardiac output during the weaning trial. The primary reason for the lack of success may not be a cardiac problem, but the lack of augmentation of cardiac output suggests the presence of cardiac dysfunction as a contributing factor. The lack of augmentation may be due to the presence of an underlying systolic or diastolic dysfunction or cardiac ischemia that becomes relevant during the stress of weaning. Successful weaning from mechanical ventilation depends on the extent of recovery from the primary reason for respiratory failure and the extent of cardiac reserve available to support the effort and the physiological changes related to the change to spontaneous breathing.\(^{5,17,18}\)

Most weaning protocols do not address the reason for an unsuccessful SBT. A patient’s trial may be unsuccessful because of previously unknown premorbid conditions or other factors that ensued during the acute illness,\(^{19}\) some of which may not be readily detectable by bedside assessment. A noninvasive cardiac output monitor provides a feasible method for assessing cardiac function during weaning. We examined noninvasive measurement of cardiac output during an SBT. At baseline, cardiac output did not differ between participants who later did or did not have a successful SBT, indicating that assessment of resting cardiac function does not identify patients at risk for unsuccessful weaning. In contrast, participants who had an unsuccessful SBT were unable to augment cardiac output as early as 5 minutes into the trial and to sustain this augmentation throughout the trial, suggesting the presence of cardiac dysfunction. Alternatively, the ability to augment cardiac output during an unsuccessful weaning trial may indicate noncardiac causes, such as muscle weakness, malnutrition, increased resistive or elastic loads, endocrinopathies, or anxiety, as the cause of the lack of success.\(^{19,20,21}\)

Previous research\(^{4}\) indicates that a major proportion of patients who have an unsuccessful SBT have associated cardiac dysfunction. Using an invasive measure of intravascular pressure, Jubran et al\(^{22}\) compared the continuous recording of mixed venous oxygen saturation in patients whose weaning trial was successful with that of patients whose trial was unsuccessful. At baseline, the measurements were similar, but saturation values decreased progressively during an unsuccessful weaning trial, whereas a successful weaning trial was characterized by an increase in cardiac index. Similar to other researchers, we found that baseline hemodynamic values do not help in predicting weaning outcomes. Chien et al\(^{23}\) found no difference in baseline BNP levels for patients in whom weaning was unsuccessful, but patients in whom extubation was unsuccessful had significantly higher levels of BNP at the end of the trial. The possibility of managing fluid levels on the basis of BNP levels during weaning was tested by Mekontso-Dessap et al\(^{24}\) in a randomized control trial. Patients had fluid intake restricted and were given furosemide and acetazolamide when the daily BNP level was more than 200 pg/mL. The intervention resulted in more ventilator-free days, and patients with left ventricular dysfunction benefited more from the strategy. Grasso et al\(^{25}\) found that N-terminal-proBNP levels were higher at the end of the weaning trial in patients with chronic obstructive pulmonary disease who had difficulties in weaning than in patients with acute cardiac dysfunction.

Frazier et al\(^{4}\) correlated cardiac output measured by using a technique similar to our technique and noted that patients in whom weaning was unsuccessful had increased serum levels of catecholamine and electrocardiographic evidence of excessive ectopy. Lamia et al\(^{26}\) assessed the feasibility of using transthoracic echocardiography by determining the early and late ventricular filling velocity and the early peak mitral diastolic velocity by Doppler transmitral flow during weaning. Pulmonary artery

![Figure](https://example.com/figure.png)
occlusion pressure was used as a surrogate for left ventricular filling pressures. These researchers concluded that the combination of a ratio of early to late ventricular filling velocities greater than 0.95 and a ratio of early ventricular filling to early peak mitral diastolic velocities greater than 8.5, measured at the end of the SBT, allowed accurate noninvasive detection of weaning-induced elevation in pulmonary artery occlusion pressure. Although these findings are promising, the feasibility of real-time testing during SBTs remains to be demonstrated in clinical settings. Our results indicate that noninvasive cardiac output monitoring can be applied during routine weaning. Real-time monitoring during weaning may have advantages over timing the collection of blood samples to measure levels of cardiac markers or continuous bedside echocardiography. The inability to augment cardiac output from baseline during an unsuccessful weaning trial would prompt clinicians to consider cardiac causes for failure and carefully direct therapeutic interventions, with a goal of improving cardiac status. Conversely, an unsuccessful weaning trial despite an ability to augment cardiac output may indicate a need to focus on noncardiac causes for the lack of success.

Our study had some limitations. First, it was a single-site pilot study with a relatively small sample size, and no sample size analysis was conducted. Although our sample was more numerous than that in a similar investigation, our method and results require validation in a larger trial. Second, the accuracy of the carbon dioxide rebreathing method in spontaneously breathing patients was questioned by Tachibana et al. These investigators compared noninvasive measurements with measurements obtained by using the thermodilution method and a pulmonary artery catheter while patients were spontaneously breathing with pressure support ventilation and concluded that the results of rebreathing methods correlated well with those of the thermodilution method. The measurement bias that might occur because of lower tidal volume and irregular breathing pattern during an unsuccessful SBT would result in a false overestimation, rather than an underestimation, of cardiac output. The carbon dioxide rebreathing method, similar to other invasive or noninvasive methods for obtaining hemodynamic measurements, has limitations, and care providers should always interpret results from a clinical perspective. Third, participants in whom the SBT was unsuccessful generally augmented cardiac output by less than 10%. However, an analysis of a receiver operating characteristic curve did not indicate a high degree of accuracy in using the 10% threshold to predict weaning outcome. Last, our study was not designed to address the effect of interventions on subsequent weaning outcomes.

Conclusion

A noninvasive method for assessing cardiac output can be easily applied to patients during weaning from mechanical ventilation. Unsuccessful weaning is characterized by an inability to augment cardiac output from baseline measurements obtained before the start of weaning. Although further investigation is warranted, noninvasive measurement of cardiac output appears to identify patients whose weaning trials are unsuccessful because of cardiac causes, allowing goal-directed interventions to expedite the weaning process.

ACKNOWLEDGMENT

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FINANCIAL DISCLOSURES

None reported.

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REFERENCES


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Background
Although many patients with chronic obstructive pulmonary disease (COPD) require a prolonged length of stay (PLOS) following coronary artery bypass grafting (CABG), the impact of PLOS on long-term survival has not been examined in this population.

Objectives
To determine the association between PLOS and long-term survival among COPD and non-COPD patients after CABG and to examine consequent policy and practice-based implications.

Methods
A retrospective cohort study of CABG patients was conducted between 2002 and 2011. Long-term survival was compared in patients with and without COPD and stratified by PLOS. Hazard ratios (HR) and 95% confidence intervals (CI) were computed using a Cox regression model.

Results
A total of 203 patients (4.2%) had PLOS after nonemergent CABG (N = 4801). PLOS was an important independent predictor of decreased long-term survival (no COPD, no PLOS: HR = 1.0; COPD, no PLOS: adjusted HR [95% CI], 1.8 [1.5-2.1]; no COPD, PLOS: 3.3 [2.5-4.4]; COPD, PLOS: 6.0 [4.4-8.2]; P_Trend < .001).

Conclusions
COPD and PLOS are 2 of many factors that affect long-term mortality in postoperative CABG patients. Aggressive treatment strategies aimed at early weaning off of mechanical ventilation and prevention of reintubation among COPD patients must be considered carefully as a means to reduce length of stay after CABG. Our results also have important implications for the long-term management of these patients and strategies for containing costs over the life course of the patient.

Chronic obstructive pulmonary disease (COPD) is a progressive pathologic process that includes bronchitis and emphysema. Symptoms include chronic cough, dyspnea, and sputum production.1 This condition affects an estimated 16 million Americans and recently has become the third leading cause of death in the United States.1,2

The prevalence of COPD among coronary artery bypass grafting (CABG) patients varies from 11% to 25.8%.3-5 Among CABG patients, COPD is a predictor of prolonged length of stay (PLOS), prolonged mechanical ventilation, and postoperative complications (eg, pneumonia).6-9 COPD also is an important predictor of long-term survival following CABG.3-5 However, little is known about the synergistic effect of PLOS and COPD on survival. COPD is an important topic to investigate in this era of cost containment and comparative effectiveness research. Ventilator hours, intensive care unit days, long-term survival, and total costs are areas with opportunities for improvement in the postoperative care and long-term management of COPD patients with coronary artery disease.

PLOS after cardiac surgery has a negative influence on long-term survival.10-13 For example, a prolonged stay greater than 3 days in the critical care unit was negatively associated with survival 3 years after cardiac surgery, with postoperative respiratory failure a predictor of a prolonged stay.11 However, no preoperative risk assessment for respiratory comorbidity was noted, and follow-up of patients for only 3 years limited the data captured on long-term survival. Although COPD patients are more likely to require PLOS following surgery, the impact of hospital PLOS on long-term survival has not been examined in these patients after cardiac surgery. The purposes of our study were to determine the association between PLOS and long-term survival among COPD and non-COPD patients after CABG and to examine consequent policy and practice-based implications.

Methods

The institutional review board at East Carolina University reviewed and approved this study. Details of the database have been previously described and are summarized in the following paragraphs.14-21

Study Design

This was a retrospective analysis of a prospectively maintained database of patients undergoing first-time, isolated CABG at the East Carolina Heart Institute between 2002 and 2011. Demographic data, comorbid conditions, coronary artery disease severity, and surgical data were collected at the time of surgery. Patients with and without COPD were compared and stratified by PLOS. Only black and white patients were included, so as to minimize the potential for residual confounding (~1% other races). Racial identity was self-reported. Emergent cases (n = 105) were considered a clinically different population with a unique postoperative course and were excluded from our analysis, resulting in the final sample to address the purpose of this study (N = 4801).

Definitions

COPD was classified preoperatively on the basis of severity by using the following Society of Thoracic Surgeons (STS) database criteria: “Mild: forced expiratory volume in 1 second (FEV1) 60% to 75% of predicted, and/or on chronic inhaled or oral
The National Death Index was used to ascertain death dates for patients lost to follow-up. Because it limits the influence of outliers and allows assessment of trends across categories.

Follow-up was defined as the time from surgery to the date of death or censoring (loss to follow-up or end of follow-up). Survival probabilities were computed by using the Kaplan-Meier product-limit method and stratified by COPD and PLOS. An important advantage of this technique is that all patients do not need to be observed for the entire study period. Moreover, rather than being grouped into intervals as is commonly done in actuarial life tables, the survival time for each patient is computed separately. The log-rank test was used to compare survival between patients with and without COPD by PLOS. Cox proportional hazard regression models were used to compute mortality ratios (HRs) and 95% confidence intervals (CIs). Often used to estimate relative risk, HRs represent the relative instantaneous incidence of mortality between 2 groups. Cox regression is similar to traditional regression, with the exception that the dependent variable signifies the logarithm of the incidence rate and accounts for various lengths of time for follow-up. In a Cox regression model, “independent variables are used to model the risk (or hazard) of experiencing an event at a given point in time, given that one has not experienced the event before that time.” Multivariable models included variables that have been previously reported to be associated with cardiovascular-related mortality, regardless of their statistical significance in our dataset. These included age, sex, race, hypertension, coronary artery disease severity, heart failure, and prior stroke. The post-hoc addition of other variables into the model was tested in a pairwise fashion. The method of Grambsch and Therneau was used to confirm the proportional hazards assumption.
Statistical significance for categorical variables was tested by using the Fisher exact test for 2×2 comparisons and a χ² test for multivariate comparisons. The Deuchler-Wilcoxon and Kruskal-Wallis methods were used to assess continuous variables. Trend for increasing/decreasing COPD severity by PLOS was assessed for statistical significance by using an exact Cochran-Armitage trend test. Similarly, the linear association for HRs across levels of PLOS-COPD was computed by using a likelihood ratio test, with the order of categories based on the a priori assumption of a greater force of mortality among patients with PLOS and COPD status. The analysis was stratified by 2 equal time periods to assess temporality during the study period. Missing values were present for ventilatory time (n = 6) and intensive care unit LOS (n = 372). An iterative expectation-maximization (EM) algorithm was used to account for missing values.32-34 Covariates entered into the EM algorithm included hospital LOS, patient’s age, sex, race, coronary artery disease severity, heart failure, and stroke. The imputation efficiency for the missing variables was greater than 98%. Statistical significance was defined as P less than .05. SAS Version 9.3 (SAS Institute Inc) was used for all analyses.

Results

A total of 203 patients (4.2%) had PLOS after CABG (N = 4801). COPD patients were more likely to have PLOS than were non-COPD patients (6.8% vs 3.6%; Fisher exact test, P < .001). After adjustment for age, sex, race, hypertension, coronary artery disease severity, heart failure, and prior stroke, a statistically significant linear trend for increasing COPD severity was observed among patients with PLOS (COPD: none, 4%; mild, 6%; moderate, 7%; severe, 15%) compared with patients without PLOS (COPD: none, 96%; mild, 94%; moderate, 93%; severe, 85%; Cochran-Armitage trend test, P < .001). Patients’ characteristics and univariable survival, preoperative medications, and postoperative complications are shown in Tables 1 and 2. In our study population, the percentage of patients having “Medicaid,” “Medicare,” “Medicaid/Medicare,” or “no insurance” as their primary payor status significantly differed by COPD status (COPD, 76%; non-COPD, 68%; Fisher exact test P < .001, not shown in tables). Furthermore, this payor group was significantly associated with worse long-term survival (adjusted HR = 1.9, 95% CI = 1.5-2.4) than patients who had private or military insurance. The median follow-up for study participants was 4.4 years.

Kaplan-Meier unadjusted survival curves are shown in the Figure. Five-year survival rates for non-COPD patients with and without PLOS were 54% and 88%, respectively. The 5-year survival rates for COPD patients with and without PLOS were 30% and 76%, respectively. Among patients without PLOS, the survival probability of patients with COPD versus those without COPD diverged. This trend was not observed for PLOS patients.

PLOS was observed to be a statistically significant predictor of decreased survival in COPD patients following CABG (Table 4). The multivariable results did not substantively change with the pairwise addition of variables listed in Tables 1 and 2, as well as left main coronary artery disease, recent smoker status, peripheral arterial disease, prior myocardial infarction, and prior percutaneous coronary intervention.

Discussion

Several studies10-13 have shown an inverse association between LOS in the intensive care unit after cardiac surgery and long-term survival. COPD is a predictor of PLOS and long-term survival following CABG.3-5 To our knowledge, no studies have been published yet regarding the synergistic impact of PLOS on long-term survival among COPD patients after CABG.

Although postoperative complications were associated with PLOS for both COPD and non-COPD patients, COPD patients in our study were more likely than non-COPD patients to have postoperative development of pneumonia and acute respiratory distress syndrome, which required reintubation and prolonged ventilation. This reflects previous reports on this topic.6-9 Also similar to prior studies,10-13 payor status was associated with PLOS in our analysis. Because maintaining airway pressures of 10 cm H₂O has been observed to significantly reduce atelectasis, pneumonia, and reintubation,37,38 prophylactic continuous positive airway pressure may benefit COPD patients following CABG. Furthermore, in patients already receiving mechanical ventilation, aggressive pulmonary physiotherapy and early tracheostomy have been observed to reduce duration of mechanical ventilation and hospital LOS.39,40 The influence of these practices on long-term survival among COPD patients after CABG warrants further investigation.

Patients with PLOS had noticeably higher short-term mortality than did patients without PLOS, regardless of COPD status. However, it appears that COPD may have a more sustained influence on long-term mortality than PLOS has, as illustrated by the continuing separation of the
“no PLOS” Kaplan-Meier survival curves shown in the Figure. Similarly divergent survival curves for COPD versus no COPD (not stratified by PLOS) were observed in the Northern New England Cardiovascular Disease Study analysis of 33 137 consecutive patients undergoing isolated CABG from 1992 through 2001. Although we do not have a definitive explanation for this phenomenon, it conceivably may reflect a differential interaction with specific long-term sequelae, such as suboptimal follow-up care, inappropriate specialist referral, or inadequate health literacy of patients. The observation also may be attributed in part to underlying comorbid conditions such as diabetes, vascular disease, renal failure and renal insufficiency, peptic ulcer, cancer, and chronic heart failure. In contrast, an early dominance effect of PLOS is noted by the parallel survival curves for COPD versus no COPD among patients with PLOS. Further examination of long-term factors associated with PLOS and COPD may assist in understanding this phenomenon.

Our results have important implications regarding the postoperative and long-term costs associated with COPD and PLOS following CABG. The medical

### Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) of patients with no COPD</th>
<th>No. (%) of patients with COPD</th>
<th>Univariable HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No PLOS</td>
<td>PLOS</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>Overall</td>
<td>3681 (77)</td>
<td>136 (3)</td>
<td>NA</td>
</tr>
<tr>
<td>Age, years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1 (≤56)</td>
<td>971 (26)</td>
<td>16 (12)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q2 (56-64)</td>
<td>967 (26)</td>
<td>28 (21)</td>
<td></td>
</tr>
<tr>
<td>Q3 (64-72)</td>
<td>959 (26)</td>
<td>39 (29)</td>
<td></td>
</tr>
<tr>
<td>Q4 (&gt;72)</td>
<td>784 (21)</td>
<td>53 (39)</td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>63 (10)</td>
<td>69 (9.9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Median (range)</td>
<td>64 (26-90)</td>
<td>70 (44-87)</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2630 (71)</td>
<td>93 (68)</td>
<td>.44</td>
</tr>
<tr>
<td>Female</td>
<td>1051 (29)</td>
<td>43 (32)</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>2866 (78)</td>
<td>101 (74)</td>
<td>.34</td>
</tr>
<tr>
<td>Black&lt;sup&gt;c&lt;/sup&gt;</td>
<td>815 (22)</td>
<td>35 (26)</td>
<td></td>
</tr>
<tr>
<td>Body mass index&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obese (&lt;30)</td>
<td>1660 (45)</td>
<td>56 (41)</td>
<td></td>
</tr>
<tr>
<td>Overweight (25-29.9)</td>
<td>1411 (38)</td>
<td>50 (37)</td>
<td></td>
</tr>
<tr>
<td>Normal (18.5-24.9)</td>
<td>594 (16)</td>
<td>28 (21)</td>
<td>.13</td>
</tr>
<tr>
<td>Underweight (&lt;18.5)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16 (-1)</td>
<td>2 (1)</td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>30 (5.7)</td>
<td>29 (6.1)</td>
<td>.17</td>
</tr>
<tr>
<td>Median (range)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>29 (13-66)</td>
<td>29 (14-48)</td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>1854 (50)</td>
<td>55 (40)</td>
<td>.02</td>
</tr>
<tr>
<td>Nonelective&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1827 (50)</td>
<td>81 (60)</td>
<td></td>
</tr>
<tr>
<td>Payer status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private/military</td>
<td>1214 (33)</td>
<td>21 (15)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Medicaid/Medicare/self&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2467 (67)</td>
<td>115 (85)</td>
<td></td>
</tr>
<tr>
<td>Recent smoker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2727 (74)</td>
<td>107 (79)</td>
<td>.27</td>
</tr>
<tr>
<td>Yes&lt;sup&gt;c&lt;/sup&gt;</td>
<td>954 (26)</td>
<td>29 (21)</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2235 (61)</td>
<td>74 (54)</td>
<td>.15</td>
</tr>
<tr>
<td>Yes</td>
<td>1446 (39)</td>
<td>62 (46)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; HR, hazard ratio; NA, not applicable; PLOS, prolonged length of stay; Q1, quartile 1; Q2, quartile 2; Q3, quartile 3; Q4, quartile 4. Tests of statistical significance (Fisher exact test for categorical variables, Deuchler-Wilcoxon test for continuous variables). COPD versus no COPD. P<0.01 (χ² for categorical variables and Kruskal-Wallis for continuous variables; across all columns). Calculated as weight in kilograms divided by height in meters squared.
### Table 2
Preoperative medications (N = 4801)

<table>
<thead>
<tr>
<th>Medication</th>
<th>No. (%) of patients with no COPD</th>
<th>No. (%) of patients with COPD</th>
<th>p^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>3681 (77)</td>
<td>917 (19)</td>
<td>NA</td>
</tr>
<tr>
<td>Aspirin</td>
<td>2932 (80)</td>
<td>718 (78)</td>
<td>.83</td>
</tr>
<tr>
<td>Lipid-lowering agents</td>
<td>2631 (71)</td>
<td>655 (71)</td>
<td>.25</td>
</tr>
<tr>
<td>Anticoagulants</td>
<td>1344 (37)</td>
<td>361 (39)</td>
<td>.37</td>
</tr>
<tr>
<td>Antiplatelet agents^b</td>
<td>847 (23)</td>
<td>209 (23)</td>
<td>.001</td>
</tr>
<tr>
<td>β-Blockers</td>
<td>2832 (77)</td>
<td>680 (74)</td>
<td>.76</td>
</tr>
<tr>
<td>Calcium channel blockers</td>
<td>708 (19)</td>
<td>177 (19)</td>
<td>.22</td>
</tr>
<tr>
<td>Diuretics^b</td>
<td>754 (20)</td>
<td>244 (27)</td>
<td>.02</td>
</tr>
<tr>
<td>ACE inhibitors/ARBs^c</td>
<td>1601 (43)</td>
<td>439 (48)</td>
<td>.54</td>
</tr>
<tr>
<td>Digitalis^b</td>
<td>125 (3)</td>
<td>54 (6)</td>
<td>.008</td>
</tr>
<tr>
<td>Nitrates</td>
<td>443 (12)</td>
<td>118 (13)</td>
<td>.23</td>
</tr>
<tr>
<td>Inotropic agents^b</td>
<td>25 (1)</td>
<td>14 (2)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin-receptor blocker; COPD, chronic obstructive pulmonary disease; NA, not applicable; PLOS, prolonged length of stay.

^a Fisher exact test.

^b P < .01 (χ^2, across all columns).

^c P < .05 (χ^2, across all columns).

### Table 3
Postoperative outcomes (N = 4801)

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. (%) of patients with no COPD</th>
<th>No. (%) of patients with COPD</th>
<th>p^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>3681 (77)</td>
<td>917 (19)</td>
<td>NA</td>
</tr>
<tr>
<td>Myocardial infarction^b</td>
<td>7 (&lt;1)</td>
<td>1 (&lt;1)</td>
<td>.13</td>
</tr>
<tr>
<td>Stroke^b</td>
<td>25 (1)</td>
<td>11 (1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>ARDS^b</td>
<td>11 (&lt;1)</td>
<td>10 (1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pneumonia^b</td>
<td>23 (1)</td>
<td>11 (1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Renal failure^b</td>
<td>55 (1)</td>
<td>17 (2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Reintubation^b</td>
<td>41 (1)</td>
<td>20 (2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Ventilator time, hours^b,d</td>
<td>12 (12)^f</td>
<td>14 (19)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Median (range)</td>
<td>9.1 (&lt;1-232)^f</td>
<td>10 (&lt;1-312)</td>
<td></td>
</tr>
<tr>
<td>ICU LOS, hours^b,d,e</td>
<td>33 (33)^d</td>
<td>37 (32)^d</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>342 (648)^d</td>
<td>409 (563)^d</td>
<td></td>
</tr>
<tr>
<td>Median (range)</td>
<td>129 (&lt;1-5030)^d</td>
<td>270 (&lt;1-4057)^d</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ARDS, acute respiratory distress syndrome; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; LOS, length of stay; NA, not applicable; PLOS, prolonged length of stay.

^a Tests of statistical significance (Fisher exact test for categorical variables, Deuchler-Wilcoxon test for continuous variables).

^b P < .01 (χ^2 test for categorical variables and Kruskal-Wallis test for continuous variables, across all columns).

^c Data unknown for 6 patients.

^d Estimates imputed by using the expectation-maximization algorithm.

^e Data unavailable in Society of Thoracic Surgeons database version 2.35 (n = 372).

^f Operative mortality was defined as any cause of death within 30 days after coronary artery bypass graft surgery in or out of our hospital and after 30 days during the same hospitalization following surgery.
The mean baseline cost for CABG is $26,056 per surgery, but the cost associated with prolonged mechanical ventilation increases this mean cost by approximately $40,704. Furthermore, the long-term cost per patient for a 12-year period has been estimated at $123,000, with an additional 2.3% increase attributable to comorbid conditions. The preceding estimates highlight the importance of identifying patients who may be at highest risk for poor outcomes following CABG to guide future decision making and resource planning. This point is particularly salient in the context of cardiac rehabilitation, which has been associated with reduced postoperative morbidity and improved long-term survival in CABG patients. However, patients with COPD and other morbid conditions are significantly less likely to attend cardiac rehabilitation. Additionally, among patients eligible for Medicaid or Medicare, only 5.2% attend cardiac rehabilitation compared with 20.3% of noneligible patients.

The percentage of patients in our study without private insurance as their primary payor status differed significantly by COPD status. Furthermore, this payor group experienced significantly worse long-term survival than did patients having private or military insurance. Our findings are similar to results of a large 12-year, retrospective cohort study, which reported a 1.5-fold HR (95% CI = 1.1-2.1) for mortality associated with Medicaid insurance. Conceivably, patients with both COPD and PLOS represented a population of patients at the extreme end of the severity spectrum that may be more susceptible to the impact of payor type.

The results of this study have important implications for the long-term management of patients with COPD undergoing CABG. Primary care providers may use this information to design interventions cost attributable to COPD in the United States during 2010 was approximately $32 billion, with absenteeism accounting for $4 billion in added costs. The mean baseline cost for CABG is $26,056 per surgery, but the cost associated with prolonged mechanical ventilation increases this mean cost by approximately $40,704. Furthermore, the long-term cost per patient for a 12-year period has been estimated at $123,000, with an additional 2.3% increase attributable to comorbid conditions. The preceding estimates highlight the importance of identifying patients who may be at highest risk for poor outcomes following CABG to guide future decision making and resource planning. This point is particularly salient in the context of cardiac rehabilitation, which has been associated with reduced postoperative morbidity and improved long-term survival in CABG patients. However, patients with COPD and other morbid conditions are significantly less likely to attend cardiac rehabilitation. Additionally, among patients eligible for Medicaid or Medicare, only 5.2% attend cardiac rehabilitation compared with 20.3% of noneligible patients.

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aimed at decreasing postdischarge risk factors and to appropriately coordinate the ongoing care of their patients in a multimodal environment of clinical specialists and social workers. The information also may be useful when conversing with patients, aiding them to set realistic expectations of their outcomes and prompting lifestyle behavioral changes.

One effective intervention that may explain the differential survival curves is participation in pulmonary rehabilitation that combines education and exercise training of patients. Such rehabilitation remains a key factor in the postoperative management of COPD patients and improving health-related quality of life. However, the careful monitoring and intervention of COPD symptoms, distress, and impaired functional status associated with fatigue, dyspnea, and depression also merit close attention on the part of health care providers. For example, the prevalence of fatigue among COPD patients has been estimated to be as high as 71%, and fatigue is associated with an increase in the severity of pulmonary impairment and COPD exacerbations. Fatigue also is believed to adversely affect enrollment and participation, while increasing attrition in pulmonary rehabilitation programs. Because COPD patients with fatigue benefit from enrollment in a 12-week rehabilitation program, assessing for this symptom, especially in the context of PLOS, and encouraging participation in rehabilitation are warranted.

Health care providers also may play an important role in the immediate and long-term postoperative outcomes of CABG patients with COPD through the design and implementation of self-management interventions aimed at teaching patients the skills and behaviors necessary to optimally manage their disease. In a Cochrane review of 23 studies on COPD patients participating in self-management, a statistically significant improvement in health-related quality of life was found when compared with patients undergoing usual care. Self-management also was associated with a decreased probability of hospitalization related to a respiratory problem.

Our findings raise important questions regarding the medical management of COPD and consequent long-term costs. Although CABG provides definitive symptomatic relief for COPD patients with coronary artery disease, medical management (eg, medication, lifestyle intervention, behavioral modification) may be acceptable in certain cases in lieu of surgery. Risk stratification models aimed at identifying patients at higher or lower risk of PLOS and the consequent impact on survival may facilitate the decision regarding the medical versus surgical management of COPD patients with coronary artery disease.

**Strengths and Limitations**

The current study is strengthened by its comparatively large sample size and long-term follow-up. Furthermore, we were able to determine time of death accurately by using a combination of the NDI and our comprehensive EMR.

Several limitations are inherent in our analysis. Survival after CABG among COPD patients varies by pulmonary disease severity. Pulmonary function tests, such as measurement of FEV1, values, were not repeated before surgery, and the effect of medical therapy may have resulted in some misclassification of COPD severity. However, COPD status was classified as a binary variable in our main analysis, and the misclassification of HRs by severity most likely would have biased results toward the null.

Previous studies have shown that administration of corticosteroids is associated with PLOS after adjusting for scores on the Acute Physiology and Chronic Health Evaluation II. However, we adjusted for several other variables accounting for the patient’s overall condition and need for supportive medications. Further inclusion of corticosteroids and similar medications in our model most likely would have resulted in overadjustment. Additionally, corticosteroids commonly are used to treat exacerbations and as maintenance therapy in COPD; therefore, we opted not to adjust for a variable that potentially is in the causal pathway.

Socioeconomic position, education, and income were not collected in our database and these factors may have influenced survival. Additionally, we were unable to reliably estimate socioeconomic position by using zip codes because a large percentage of patients in our catchment area live in rural areas with postal box addresses.

Patients in this study were recruited for a relatively long period (10 years), and practice methods and clinical care may have changed during this time. However, results were consistent when the analysis was stratified by 2 time periods, indicating the robustness of the data to temporal changes. Furthermore, the status of some variables in our analysis may have changed during the study period. We did not adjust for these variables in a time-dependent fashion because of their potential to be in the causal pathway.

Cause of death is not recorded in the NDI, and COPD status may have been unrelated to patient mortality. Although we adjusted for known clinically relevant variables, other unmeasured factors could have influenced our results; retrospective
studies are susceptible to recall and selection biases. The association between COPD and poor survival could be noncausal in nature or related to noncardiac causes.60

COPD was classified according to the STS criteria, and the findings of our study must be interpreted accordingly when making comparisons with other COPD staging systems such as the Global Initiative for Chronic Obstructive Lung Disease (GOLD) and the Body Mass Index, Airflow Obstruction, Dyspnea and Exercise Capacity (BODE) systems.61-64 The American Thoracic Society (ATS) and the European Respiratory Society (ERS) updated the Standards for the Diagnosis and Treatment of Patients with COPD in 2004 to provide guidance beyond the broad GOLD initiative. Both the GOLD and ATS/ERS guidelines are similar in classification and note the limitations of a staging system using FEV1 in this complex patient population. Additionally, both guidelines note that the value of preoperative pulmonary function testing is undetermined in general surgery patients who have COPD. Finally, the STS classification system does not take into consideration extrapulmonary abnormalities such as obesity-related hypoventilation syndrome, pulmonary hypertension, and deconditioning. Consequently, these conditions were not accounted for in our analyses.

Conclusion

PLOS is a significant predictor of long-term survival in CABG patients, and our study demonstrates that this postoperative course is complicated by the presence of COPD. Following surgery, these patients may have a longer LOS than the general CABG population attributable to their pulmonary disease, which predisposes them to atelectasis, pneumonia, acute respiratory failure, and reintubation. Additional health service analysis is needed to determine if improved health insurance coverage, performance tracking, and outcome incentives will increase the long-term survival of COPD patients undergoing CABG. Future studies should evaluate the impact of treatment strategies and quality improvement measures as a means to decrease PLOS and improve long-term survival. Such evaluation is especially relevant to strategies and measures implemented during the acute phase and aimed at minimizing the incidence and duration of invasive mechanical ventilation.

FINANCIAL DISCLOSURES

None reported.

eLetters

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Notice to CE enrollees:
This article has been designated for CE contact hour(s). The evaluation tests your knowledge of the following objectives:

1. Define the 3 severities of chronic obstructive pulmonary disease recognized by the Society of Thoracic Surgeons.
2. Identify the optimal continuous positive airway pressure for chronic obstructive pulmonary disease patients following coronary artery bypass grafting.
3. Interpret the unadjusted Kaplan-Meier survival curves in the figure.

To complete evaluation for CE contact hour(s) for test A1625032, visit www.ajcconline.org and click the "CE Articles" button. No CE test fee for AACN members. This test expires on January 1, 2019.

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Diabetes mellitus, caused by a deficiency of the pancreatic hormone insulin, affects millions of individuals every year. In the United States, 29.1 million people had a diagnosis of diabetes in 2012 (9.3% of the US population). Worldwide, the World Health Organization reported 415 million adults with diabetes.1 As the seventh leading cause of death in the United States, diabetes claimed 69,071 lives in 2012.2 Many complications and comorbid conditions are associated with diabetes including myocardial infarction (1.8 times higher risk), stroke (1.5 times higher risk), and cardiovascular deaths (1.7 times higher risk). In adults, diabetes is the most common cause of nontraumatic lower-limb amputations, kidney failure that results in the need for chronic dialysis or kidney transplant, and vision loss/impairment.3

Diabetic ketoacidosis (DKA) is the most serious acute metabolic complication of diabetes. Hospitalizations for DKA in the United States are on the rise. According to epidemiological studies, DKA increased 35% from 1996 to 2006, with primary diagnoses of DKA totaling 136,500 in 2006. Two-thirds of DKA patients are type 1 diabetics, with the majority either between 18 and 44 years old or more than 65 years old. Although overall mortality is low (<1%), higher mortality is seen in older adults and those with life-threatening conditions.4 In addition, the direct and indirect costs incurred for the acute management of DKA exceed $2 billion annually.5,6 Successful treatment of DKA requires correction of dehydration, hyperglycemia, and electrolyte imbalances. Hyperglycemia during acute illness results from increased hepatic glucose production and impaired glucose use in peripheral tissues. Excess counter-regulatory hormones such as glucagon, cortisol, and catecholamines increase lipolysis and protein breakdown, also leading to impaired glucose use by peripheral tissues. Further, hyperglycemia increases inflammatory cytokines and leads to immune system dysfunction. These are just a few of the changes that can eventually lead to increased risk of infection, impaired wound healing, multiple organ failure, prolonged hospital stay, and death.4,6,9

The core treatment of DKA involves the administration of regular insulin via continuous intravenous infusion. This route is preferred because of the short half-life (7 minutes) and easy titration of regular intravenous insulin. Hypoglycemia and hypokalemia are common complications of extreme treatment of DKA with an insulin infusion and thus, the nurses’ role in monitoring blood glucose levels, electrolyte levels, and anion gap is critically important. Anion gap calculation can be done quickly by using the following formula: (serum Na+ + serum K+) - (serum Cl- + serum CO2).

More recently, newer options for the treatment of DKA have been studied to determine their safety and effectiveness. Thus, the PICO (patient/problem, intervention, comparison, outcomes) question of interest for this review was, In patients receiving an intravenous insulin infusion for DKA, will the co-administration of subcutaneous long-acting insulin within 2 to 4 hours of starting an insulin infusion improve recovery from DKA and other clinical and financial outcomes?

Method

A search of the MEDLINE and CINAHL databases was conducted by using these terms: diabetic ketoacidosis, intravenous insulin, long-acting insulin, and subcutaneous insulin. Hand searching was also performed. The review was limited to the last 5 to 7 years for adult patients only.

Results

Three studies were retrieved (Table 1). These studies compared regular insulin infusions for the treatment of DKA versus regular insulin infusions with the addition of subcutaneous long-acting insulin...
of long-acting subcutaneous glargine. Main outcomes examined included amount of intravenous infusion, time to anion gap closure, hypoglycemia events, rebound hyperglycemia after the infusion, and length of stay.

The studies differed in the dose (0.25, 0.3, 0.4 U/kg) and the timing of the subcutaneous glargine (2, 3, or 12 hours) with respect to initiation of the regular insulin infusion. Daily administration of subcutaneous glargine was consistent across studies. No significant differences were found in outcomes between the control and experimental conditions in all studies with the exception of rebound hyperglycemia.

### About the Authors

**Margo A. Halm** is the director of nursing research, professional practice, and Magnet at Salem Hospital in Salem, Oregon. **Sandra Bunn** is a diabetes clinical nurse specialist at Salem Health in Salem, Oregon.

**Corresponding author:** Sandra Bunn, RN, MSN, CDE, ACNS-BC, Salem Health, Salem, OR 97310 (e-mail: Sandra.bunn@ salemhealth.org).
In 2 studies, the percentage of patients who received the long-acting subcutaneous glargine had significantly less rebound hyperglycemia at either 12 or 24 hours after infusion.

**Recommendations for Practice**

The 3 studies included in this review were level B evidence (Table 2). Although these recent randomized controlled trials enrolled small samples (N = 40-61), some evidence suggests that long-acting subcutaneous glargine (0.25-0.4 U/kg) initiated around the time of a regular insulin infusion reduces rebound hyperglycemia 12 to 24 hours after DKA recovery when regular insulin infusions are typically discontinued. Other clinical and financial outcomes were not affected with the addition of subcutaneous glargine. The nonsignificance in the time to DKA recovery and length of hospital stay may be related to the small sample sizes of these investigations. Thus, larger trials are needed to test the superiority of the coadministration of long-acting insulin with intravenous regular insulin over standard care in the acute management of DKA.10,11

Extensive data indicate that uncontrolled hyperglycemia is associated with adverse outcomes in critically ill patients. Recent consensus guidelines recommend a capillary blood glucose goal range of 140 to 180 mg/dL (to convert to millimoles per liter, multiply by 0.055) in acute critical illness—while avoiding severe hypoglycemia.8 Until further research validates the effectiveness of co-administration of long-acting insulin in the setting of DKA, guidelines are needed to pave a smooth transition from the administration of intravenous insulin to the subcutaneous route.14 In a pilot observational study, critically ill patients switched from intravenous insulin to subcutaneous insulin via a standard protocol had better glycemic control than did patients whose insulin infusions were switched without using a standard protocol.15 Kitabachi et al4 emphasized the need for a 1- to 2-hour overlap between discontinuation of intravenous insulin and the administration of long-acting subcutaneous insulin to prevent a recurrence of hyperglycemia and ketoacidosis. The Endocrine Society’s clinical practice guidelines recommend that subcutaneous insulin be administered before discontinuation of continuous intravenous insulin in patients with a history of diabetes who have hyperglycemia requiring more than 2 U/h.8 Because of the short half-life of intravenous insulin, technical errors during the transitional phase of the insulin infusion can adversely affect the recovery process of DKA, specifically the occurrence of rebound hyperglycemia. Rebound hyperglycemia has the potential to increase the concentration of ketone bodies rather than decrease it, further delaying resolution of DKA and increasing length of stay in addition to increasing risk of mortality and morbidity.5,8

Few published studies have examined the effect of long-acting insulin analogues in the treatment of DKA. The 3 studies examined here demonstrate relative safety and effectiveness in using a long-acting analogue during intravenous insulin infusion. In fact, further studies are recommended by all the authors. The addition of long-acting insulin during intravenous insulin infusion for treatment of DKA appears to be safe, as the number of hypoglycemic events does not differ. Any hospital’s treatment plan for DKA should include standard criteria for initiating and discontinuing an insulin infusion.16

<table>
<thead>
<tr>
<th>Table 2</th>
<th>American Association of Critical-Care Nurses evidence-leveling systema</th>
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<tr>
<td>Level</td>
<td>Description</td>
</tr>
<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>
</tr>
<tr>
<td>B</td>
<td>Well-designed controlled studies, both randomized and non-randomized, with results that consistently support a specific action, intervention, or treatment</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>
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<tr>
<td>D</td>
<td>Peer-reviewed professional organizational standards, with clinical studies to support recommendations</td>
</tr>
<tr>
<td>E</td>
<td>Theory-based evidence from expert opinion or multiple case reports</td>
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<tr>
<td>M</td>
<td>Manufacturer’s recommendation only</td>
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<tr>
<th>Table 3</th>
<th>Quick interview and assessment tips for helping diabetic patients prevent diabetic ketoacidosis (DKA)</th>
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<tr>
<td>Interview questions and tips</td>
<td></td>
</tr>
<tr>
<td>1. How long have you had diabetes?</td>
<td></td>
</tr>
<tr>
<td>2. What do you do every day to manage your diabetes?</td>
<td></td>
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<tr>
<td>3. How often do you check your capillary blood glucose (CBG)?</td>
<td></td>
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<tr>
<td>4. What insulin(s) do you take? How much?</td>
<td></td>
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<tr>
<td>5. Do you take insulin at the same time every day?</td>
<td></td>
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<tr>
<td>6. How many doses of insulin do you miss in a week?</td>
<td></td>
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<tr>
<td>7. Do you wear an insulin pump? How often do you change your infusion set/site?</td>
<td></td>
</tr>
<tr>
<td>8. Do you have a sick day plan?</td>
<td></td>
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<tr>
<td>9. Do you take a meal time dose of insulin?</td>
<td></td>
</tr>
<tr>
<td>10. Tell me what led up to your hospitalization?</td>
<td></td>
</tr>
<tr>
<td>11. Check the patient’s injection sites for bumps, bruising, or other signs of scarring.</td>
<td></td>
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<tr>
<td>12. Does the patient have a certified diabetes educator with whom he or she communicates regularly?</td>
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</table>

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Syncope With Profound Bradycardia

By Salah S. Al-Zaiti, RN, PhD, CRNP, Michele M. Pelter, RN, PhD, Teri M. Kozik, RN, PhD, CNS, CCRN, and Mary G. Carey, RN, PhD

Scenario: Paramedics obtained this 12-lead electrocardiogram (ECG) from an 80-year-old white male with a medical history of coronary artery disease and recent myocardial infarction (< 6 months). The patient was attending morning church services, had a syncopal event, and was eased to the ground without trauma. A physician bystander reported that the patient was alert but diaphoretic with a pulse rate in the 20s. The patient was transported by ambulance to the emergency department. His blood pressure was 80/40 mm Hg, and intravenous atropine was administered en route but no change in heart rate was noted. The patient was alert, oriented, and denied associated symptoms of chest pain, nausea, vomiting or shortness of breath.

Interpretation Questions:

1. Is the ECG properly calibrated (10 mm) and are leads properly placed?  If no, interpret cautiously.
   - Yes
   - No
   - NA

2. Is this a sinus rhythm (one P wave preceding every QRS complex)?  If no, check for number of P waves in relation to QRS complexes.
   - Yes
   - No
   - NA

3. Is the heart rate (R-R interval) normal (60-100/min)?  If no, check for supra-ventricular or ventricular arrhythmias.
   - Yes
   - No
   - NA

4. Is the QRS complex narrow (duration < 110 milliseconds [ms] in V1)?  If no, check for bundle branch blocks (BBBs), pacing, or ventricular arrhythmia.
   - Yes
   - No
   - NA

5. Is the ST segment deviated (> 2 mm in V2-V3, or > 1 mm in other leads)?  If yes, check for similar deviations in contiguous cardiac territories.
   - Yes
   - No
   - NA

6. Is the T wave inverted in relation to the QRS (> 0.5 mV)?  If yes, check for ST deviation or conduction abnormalities.
   - Yes
   - No
   - NA

7. Is the QT interval lengthened (> 450 ms [men] or > 470 ms [women])?  If yes, check for ventricular arrhythmias or left ventricular hypertrophy.
   - Yes
   - No
   - NA

8. Is R- or S-wave amplitude enlarged (S wave V1 + R wave V5 > 35 mm)?  If yes, check for axis deviation or other chamber hypertrophy criteria.
   - Yes
   - No
   - NA

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Interpretation

Atrial fibrillation with complete atrioventricular block and a ventricular escape rhythm

Rationale

Progressive coronary artery disease with recent myocardial scarring could result in permanent injury to the electrical conduction system between the atria and the ventricles. This could lead to complete atrioventricular (AV) dissociation, also referred to as third degree or complete heart block.

When normal ventricular activation through the AV node is blocked, a distal area in the conduction system will initiate the heart rhythm; this becomes the “escape” pacemaker. In this case, foci in the ventricles assumed pacing, producing a slow ventricular escape rhythm that is minimally influenced by cardiac autonomic control mechanisms (eg, atropine administration). Given that these impulses do not propagate normally through the ventricular conduction system (ie, bundle branches), the result are wide QRS complexes with abnormal secondary repolarization changes (ie, changes attributable to the inhomogeneous excitation of the ventricles rather than focal myocardial pathology).

These secondary repolarization changes are manifested as discordant T waves which preclude meaningful interpretation of ST-T changes. Therefore, the slow conduction speed and ventricular inhomogeneous activation of this escape mechanism results in a slow bradycardia (<40 beats/min) and suboptimal ejection fraction. As a result, these patients may experience signs and symptoms of poor cerebral perfusion, chest pain and/or shortness of breath; thus, warranting immediate medical attention.

Management

This patient was admitted to the intensive care unit where a temporary transvenous pacemaker was emergently placed in the right ventricle, and a dopamine drip was initiated for severe hypotension. His cardiac enzymes were negative, but an urgent echocardiogram showed ischemic cardiomyopathy with ejection fraction of 20% to 25%. A dual chamber pacer with a cardioverter-defibrillator was implanted the following morning, which was well tolerated by the patient. Because the patient was in new-onset atrial fibrillation, he was placed on warfarin, an anticoagulant to help decrease the chance of developing a future stroke. The patient was discharged home on a cardiac rehabilitation program, and was scheduled for follow-up with his cardiologist.
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- Acute Kidney Injury
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- Subarachnoid Hemorrhage

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