CRITICAL CARE ALERT®

A monthly update of developments in critical care and intensive care medicine

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INSIDE

Education to Prevent Nosocomial Infections Works in Community Hospitals, Too

ABSTRACT & COMMENTARY

WARREN AND COLLEAGUES PERFORMED A NONRANDOMIZED pre- and postobservational trial of an educational intervention to prevent catheter-associated bloodstream infections (CABSIs) in a 500-bed private community hospital in Missouri. During the 16-month initial, noninterventional phase of the study, trained infection control and research nurses collected data on all patients admitted to the hospital's 2 ICUs (20 total beds). Patients were followed daily, with data collected prospectively on central venous catheters (CVCs), severity of illness, the need for mechanical ventilation, and the occurrence of ventilator-associated pneumonia and CABSIs. An educational intervention for reducing CABSIs was then implemented during a 3-month period, and the same data collected during the succeeding 13 months.

The educational intervention consisted of reporting CABSI rates to all ICU personnel, 45-minute lectures presented to nursing and medical personnel, grand rounds presented to the hospital staff on the prevention of CABSIs, and a series of posters and fact sheets distributed in the ICUs. All physicians and nurses working in the ICUs were required to complete a 10-page self-study module on CABSI prevention, with 20-question pre- and post-tests.

During the study period, 1215 (31%) of 3943 patients admitted to the ICUs had a CVC placed. Patient demographics and severity of illness (as assessed by APACHE II score) were not different before and after the educational intervention. Before the educational intervention, the rate of CABSIs was 4.9 cases per 1000 catheter-days; this fell to 2.1 cases per 1000 catheter-days following the intervention (relative risk, 0.43; 95% CI, 0.22-0.84). The proportion of CVCs inserted at the subclavian site (as opposed to internal jugular or femoral sites) increased during the postintervention period (28% vs 41%, $P < 0.001$). There were no significant changes in the timing or microbiological characteristics of CABSIs before and after the intervention, and mortality rates and

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ICU and hospital lengths of stay also did not change (Warren DK, et al. An educational intervention to prevent catheter-associated bloodstream infections in a nonteaching, community medical center. *Crit Care Med*. 2003;31[7]:1959-1963).

COMMENT BY DAVID J. PIERSON, MD

Catheter-associated bloodstream infections are a well-documented and much-studied source of increased morbidity and cost in hospitalized patients. The Centers for Disease Control and Prevention (CDC) have published evidence-based guidelines for the prevention of CABSIs,[1] which emphasize measures proven to decrease the risk of acquiring such infections (*see Table*).

More than half of all acute inpatient admissions in the United States occur in nonteaching hospitals, yet the studies used in developing current guidelines were virtually all carried out in large university-affiliated teaching hospitals. As Warren et al point out, there are important differences between teaching and nonteaching hospitals, involving nursing and physician organizational structures, patient mix, and process of care for the management of critically ill patients. This study is important because it confirms the value of currently recommended infection control measures in the nonteaching hospital setting. The incidence of CABSIs fell by 57% during the study period, and this improvement persisted throughout the 13-month postintervention period without evidence of waning.

As emphasized in the editorial accompanying the paper by Warren et al,[2] there are several barriers to the successful implementation of institution-wide changes such as those achieved in this study. Healthcare workers must first be aware of published guidelines and their recommendations. Importantly, the leadership of the groups involved (in this instance, nursing and intensivist physicians) must agree with the guidelines and support the proposed changes. Decreasing the incidence of CABSIs involves the use of certain specific products that must be made available to those placing and maintaining the catheters, so that hospital administrative buy-in is an important component of the process. As O'Grady points out in the editorial, "hospital administrators must become active partners to make it easy for healthcare providers to adhere to the guidelines and to make it equally difficult for them not to adhere to the guidelines."[2]

This study demonstrates that a focused, relatively inexpensive intervention to change ICU processes of care can be successfully implemented outside of academic medical centers and can result in persistent reductions in the incidence of nosocomial CABSIs. ■

Table

Techniques Proven to Reduce the Incidence of Catheter-Associated Bloodstream Infections

Employment of "maximal barrier precautions" during catheter insertion:

- Sterile gloves
- Gown
- Large drapes
- Surgical masks

Use of subclavian site rather than internal jugular or femoral

Avoidance of "routine" catheter changes

Prompt removal of insertion site dressing if it becomes:

- Soiled
- Bloody
- Nonocclusive

References

1. O'Grady NP, et al. Guidelines for prevention of intravascular catheter-related infections. Centers for

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Disease Control and Prevention. *MMWR Morb Mortal Wkly Rep*. 2002;51:1-29.
2. O'Grady NP. On the road to avoiding adverse events: Educational programs pave the way. *Crit Care Med*. 2003;31(7):2077-2078.

ICU Airway Management: Practice Variation, Inconsistent Evidence Base

ABSTRACT & COMMENTARY

Synopsis: *Findings from this national survey of 1665 nurses and respiratory therapists suggest that airway management practices differ widely across institutions and professions and do not consistently reflect research findings.*

Source: Sole ML, et al. A multisite survey of suctioning techniques and airway management practices. *Am J Crit Care*. 2003;12:220-232.

To determine practices regarding use of closed-system suctioning (CSS) and airway management of intubated patients, Sole and colleagues surveyed a national sample of 1665 registered nurses (RNs) and respiratory therapists (RTs) in 27 institutions. Of respondents, the majority had 6 or more years of ICU experience (61%) and a baccalaureate degree or higher (54%). The response rate was 55%, with replies received from 1186 RNs and 479 RTs. CSS was used on all intubated patients in 59% of facilities and, if specific criteria were met, in all of the remainder. CSS catheters were changed every 24-48 hours at 63% of sites, and at the remainder every 72 hours, "as needed" or weekly. Most institutions (81%) had policies that specified that respiratory therapists were to measure and record endotracheal tube cuff pressures every 8-12 hours, with the method evenly divided between minimal leak technique (48%) or a minimum cuff pressure (44%). Instillation of isotonic normal saline solution (NSS) was recommended for thick secretions in 74% of sites. Less than half (48%) of the hospitals had a specific procedure for oral care. Only 89% of respondents indicated that they wore gloves the majority of time when performing CSS. When practice differences were examined, RTs instilled NSS more often than RNs (51% vs 26%, respectively; $P < 0.05$). Compared to RTs, RNs performed oral suctioning, oral care and tooth brushing more often than RTs ($P < 0.05$). Many nurses did not know how often endotracheal tube cuff pressures were measured (38%) or the method for maintaining cuff pressures (46%). RTs said their practice was most often influenced by their educational program. RNs cited preceptors and their educational program.

COMMENT BY LESLIE A. HOFFMAN, RN, PhD

In this study, policies regarding airway management were found to vary widely and did not always reflect current research. Most sites reported changing CSS every 24-48 hours, although studies have indicated that replacement at 24-hour intervals is not necessary. The majority of sites (74%) had policies that included the instillation of NSS for thick secretions. However, prior studies investigating the efficacy of NSS instillation have consistently reported adverse effects and recommended avoiding this practice.[1] These studies have primarily been published in nursing journals, which may explain why RTs were twice as likely to instill NSS as RNs. In addition, a large majority of respondents (83%) indicated that they based their practice on information gained from their educational program, rather than more recent research publications. Few sites had policies for oral care of intubated patients despite the known association between ventilator-associated pneumonia and microaspiration of oropharyngeal secretions.

Most sites had policies for the management of endotracheal cuffs and the frequency for measuring cuff pressures. Cuff pressures should be maintained between 20 and 25 mm Hg (24-30 cm H_2O) to keep cuff pressure at a level sufficient to prevent microaspiration, but below tracheal perfusion pressure. In one study, pressures < 20 cm H_2O were associated with a 2.5-fold increase in ventilator-associated pneumonia.[2] Of concern, less than half (41%) of respondents stated that they kept cuff pressures at 20 cm H_2O or greater, and 11% said they kept cuff pressure in the range of 15 cm H_2O. Respondents indicated that use of gloves during CSS was common (89%), but not a universal practice.

Findings of this study are a concern because they suggest that practice often deviates from current research findings. While a partial explanation may be reliance on prior educational preparation and the relatively long (‡6 years) interval since graduation, Sole et al noted that there were substantial personnel resources available to provide updates, including clinical nurse specialists (74% of sites), unit-based educators (52% of sites), and respiratory therapy educators (52% of sites). Clearly, we have much progress to make in ensuring

that patient care is carried out in the most optimal manner as determined from research findings. ■

References

1. Ackerman MH, et al. A review of normal saline instillation: Implications for practice. *Dimens Crit Care Nurs*. 1996;15:31-38.
2. Rello J, et al. Pneumonia in intubated patients: Role of respiratory airway care. *Am J Respir Crit Care Med*. 1996;154:111-115.

Do Anaerobic Bacteria Cause Ventilator-Associated Pneumonia?

ABSTRACT & COMMENTARY

Synopsis: *Of 26 mechanically ventilated patients, 22 developed bacterial lower respiratory tract colonization, and in 15 patients anaerobes were recovered; 2 of 5 patients diagnosed with ventilator-associated pneumonia had anaerobes present in sufficient quantity to suggest that they were considered pathogenic.*

Source: Robert R, et al. Colonization of lower respiratory tract with anaerobic bacteria in mechanically ventilated patients. *Intensive Care Med*. 2003;29: 1062-1068.

Robert and colleagues in Poitiers, France, carried out this study to determine the frequency with which the lower airways of intubated ICU patients become colonized with anaerobic bacteria, and to see whether such colonization was associated with actual clinical pneumonia. They studied 26 patients who were intubated and mechanically ventilated within 24 hours of admission to their university hospital's ICU. They performed protected tracheal aspiration and protected tracheal brushings on the day following intubation and then twice weekly until the patients were extubated. Special techniques for recovering anaerobic bacteria were used. Ventilator-associated pneumonia (VAP) was defined using a quantitative culture threshold of 10^3 colony-forming units (cfu) per mL and the following clinical criteria: a new infiltrate on the chest x-ray that persisted at least 24 hours, plus at least 2 of the 3 signs of fever (or hypothermia), purulent tracheal aspirate, and/or leukocytosis.

Twenty-two patients (85%) became colonized by at least 1 bacterial species, 21 by aerobic organisms, and 15 by anaerobes. The latter comprised 28 isolates of 9 different species of anaerobic bacteria. Fourteen of the 15 patients with anaerobic colonization were also colonized by aerobic bacteria; only 1 had only anaerobes. Robert et al classified the colonization as early (within 5 days of intubation) in 16 of the 22 patients and late (after 5 days) in 6 patients. The criteria for VAP were satisfied by 5 patients, in 2 of whom the bacteria recovered at > 10^3 cfu/mL included anaerobes. The latter were both *Fusobacterium nucleatum* and *Prevotella melaninogenica* in both patients and also *P oralis* in 1. In 1 of these patients, *Streptococcus viridans* was also recovered in pathogenic numbers. Robert et al conclude that lower airway colonization with anaerobic bacteria is common in mechanically ventilated patients, and that these organisms may have a role in the pathogenesis of VAP.

■ COMMENT BY DAVID J. PIERSON, MD

Using specialized techniques for sampling lower respiratory tract secretions and quantitatively culturing the specimens, Robert et al recovered anaerobic bacteria from 15 of the 26 intubated patients they studied. Twenty-eight different anaerobic isolates were recovered from the 15 patients, and in all but 1 instance aerobic bacteria grew as well. While there is nothing included in the paper to make me suspect that the techniques used were faulty or that there were other study design problems, it seems odd to me that such a large proportion of the patients were colonized and/or infected concurrently by such a large number of organisms. Bronchoscopy was not used in obtaining the bacteriologic specimens, and the sampling technique used was different from that generally used by intensivists in this country. It is tempting to speculate, as Marik does in the accompanying editorial,[1] that at least some of them may have been contaminated, or at least that the organisms recovered did not constitute actual pulmonary pathogens.

Do anaerobes cause VAP? I imagine they can, but it must be exceedingly rare, and certainly much less frequent than the 40% of VAP cases observed in this study. Anaerobes rarely cause community-acquired pulmonary infections in the absence of airway occlusion, trapping the bacteria after aspiration of particulate matter from the mouth and establishing the local oxidation-reduction environment necessary for proliferation of these generally fastidious organisms. Anaerobic chest infections are often subacute, at least in their clinical features. I suppose they have to have an initial, less fulminant phase, and so it is possible that the patients in this study were in the very early stages of what is more typically

observed in patients with community-acquired anaerobic infections.

Should antibiotic treatment of suspected VAP include anaerobic coverage? Marik[1] points out that it very often does—perhaps resulting in more morbidity and mortality than would occur from untreated anaerobic infections. I am not sure what to do with the findings of this paper. For now, and until these data are replicated by investigators at other institutions, I am not inclined to change either the way I culture lower airway specimens or the way I order initial antimicrobial coverage in patients with suspected VAP. ■

Reference

1. Marik P. Aliens, anaerobes, and the lung! *Intensive Care Med*. 2003;29:1035-1037.

Special Feature

Is Insulin the ICU 'Magic Bullet'?

By Uday B. Nanavaty, MD

A WIDE VARIETY OF THERAPEUTIC INTERVENTIONS have failed to produce a significant change in the mortality of critically ill patients. Studies of these interventions include numerous trials of anti-inflammatory agents in sepsis, the trial involving growth hormone in critically ill patients, as well as a host of other investigations. Recently, from one single study, it was reported that tightly controlling blood glucose levels with insulin infusion in the surgical critical care unit resulted in significant reductions in mortality and morbidity. Numerous publications and further analysis of this one study have been published to convince intensivists that insulin infusion, adjusted based on a standard protocol, will dramatically change the outlook for patients across all ICUs. I will review the physiologic role of insulin and the limited evidence available to support this concept of tight regulation of blood glucose. My objective is to suggest that caution needs to be applied and that careful monitoring is needed if one applies this new and aggressive treatment approach—especially outside the surgical critical care setting.

Insulin: An Important Regulator of Metabolism

Insulin is a hormone normally secreted by beta cells of the islets of Langerhans of the pancreas. It is a small protein with a molecular weight of 5808 daltons. Insulin has profound effects on carbohydrate, protein, and fat metabolism. Under physiologic conditions insulin secretion is associated with energy abundance, especially with carbohydrate sources of energy. In turn, it facilitates the entry of glucose into most cells, and helps to store excess energy substances such as glycogen in liver and muscle. It causes fat storage in adipose tissue. If excess carbohydrate cannot be converted to glycogen, insulin helps to store it as adipose tissue. Overall, insulin favors use of carbohydrates as a source of energy and supports fat storage. It also helps to increase storage of proteins, almost an anabolic effect, through unclear mechanisms. By facilitating the use of glucose as the source of energy, and by facilitating glucose entry into most cells, insulin lowers blood glucose levels.

There are 4 important counter-regulatory hormones, as far as blood glucose levels are concerned. These include growth hormone and glucagon as well as cortisol and epinephrine. Epinephrine has potent glycogenolytic actions in the liver as well as more potent lipolytic effects, raising fatty acid levels. Overall, epinephrine tips the balance in favor of fat use as the source of energy during times of stress, even though it causes hyperglycemia. It is also suggested that tumor necrosis factor alpha and interleukin 1 counteract effects of Insulin.

Hyperglycemia in the Critically Ill: Stress Hyperglycemia

Hyperglycemia is considered an important predictor of increased mortality in a variety of critical illnesses. A relationship between elevated plasma glucose levels and poor outcome has been established in patients with acute myocardial infarction and stroke. In diabetic patients with acute myocardial infarction, admission hyperglycemia is considered a predictor of increased mortality, and an intensive insulin regimen to control hyperglycemia has been shown to reduce mortality at one year. This mortality benefit was most evident in diabetic patients who had not received insulin in past, and who had otherwise low cardiovascular risk.

The incidence of stress hyperglycemia is hard to define in large or general ICU populations. Studies in the 1980s suggested that stress hyperglycemia (using a threshold random blood glucose value of > 200 mg/dL) occurs in nearly half of trauma patients needing critical care and also in patients with septic shock.

In a recent report by Kitabchi et al, about 12% of all hospitalized patients had evidence of hyperglycemia, defined either as a fasting blood glucose of 126 mg/dL

or 2 or more values of random glucose > 200 mg/dL. Of these patients, about a third (29%) required ICU admission. These groups of patients with stress hyperglycemia had longer hospital lengths of stay and were less often discharged to home when compared to diabetics with hyperglycemia or patients with normoglycemia. Regardless of whether they were admitted to ICU, these hyperglycemic patients without known diabetes experienced higher mortality rate. Among ICU patients, patients with new onset hyperglycemia experienced 3-fold higher mortality rates. These newly hyperglycemic patients also experienced a higher rate of death due to infection and neurological events.

Hyperglycemia is also found in large numbers of patients undergoing cardiac surgery. It is not very well known whether these patients have a higher mortality, as most patients will have hyperglycemia in the immediate postoperative period. The incidence of hyperglycemia in medical ICUs is not well established, and its relationship with mortality or poor outcome is uncertain.

In all the ICU situations, hyperglycemia is induced as a result of the stress response. Sicker patients are more likely to have stress hyperglycemia. In the past, even if hyperglycemia was observed, it was considered a marker of severity of illness and not necessarily as a cause of increased mortality. That concept has now changed.

Tight Control of Blood Glucose: Is it Desirable?

Insulin is not the first hormone to be tried in improving the mortality of patients admitted to the ICU. Previously, human growth hormone has been tried but not recommended as it was found to lead to higher mortality in treated patients. Initial enthusiasm in evaluating another major metabolic hormone, thyroid hormone, has waned with description of terms such as sick euthyroid syndrome.

Insulin infusion was tried in cardiopulmonary bypass patients to prevent hyperglycemia during the bypass. One trial had to be halted as the investigators realized that euglycemia was hard to achieve during bypass and a large number of patients became hypoglycemic after coming off the bypass. Acute mortality from stroke does not change dramatically with insulin administration. In the diabetes mellitus, insulin glucose infusion in acute myocardial infarction study (DIGAMI), long-term mortality benefit was seen with the intensive insulin regimen. However, most of the benefit in mortality was seen after hospital discharge. In the DIGAMI study, one subgroup, patients with diabetes who were not previously treated with insulin, did receive benefit acutely as well with reduced mortality prior to hospital discharge.

In one large study, referred to as the Leuven study, Van den Berghe et al reported that intensive therapy with insulin to tightly control blood glucose values between 80 to 110 mg/dL was associated with a significant reduction in mortality in a large group of patients, mainly postcardiac surgery and other surgical ICU patients. This study used a very different cut-off value to define hyperglycemia. The goal in the experimental group was to achieve euglycemia with insulin infusion. In the control group, the aim was to keep blood glucose levels less than 200 mg/dL and not to intervene if blood glucose levels were < 180mg/dL. All patients in the study received 9 g/h of glucose infusion until feeding was started or total parenteral nutrition was initiated. Van den Berghe et al used a protocol to regulate blood glucose level in the range of 80-110 mg/dL.

This study protocol resulted in a rather profound improvement in outcome. The study group experienced not only a reduction in ICU mortality but also reduced ICU length of stay, less ventilator days, less acute renal failure, less critical illness polyneuropathy, fewer infections, and fewer blood transfusions. In my opinion, these results seem almost too good to be true.

No study these days is without criticism. One can argue that 8% mortality in a peri-operative setting may be too high. Unless we have data from a similar group of patients from the same country or similar country, we cannot make that argument. The other problem that may not have been highlighted before was that all patients were given a fixed number for their neurological status on the APACHE II score. This resulted in a lower overall APACHE score. Van den Berghe et al argue that since both groups were given similar numbers, the APACHE II is comparable. It is possible that there was some imbalance in the 2 groups that went unrecognized. The intensive insulin infusion would have required more frequent blood glucose monitoring necessitating nurses to be at the bedside perhaps a greater number of times. That could have provided a difference in monitoring of the 2 groups. Closer monitoring may improve the outcome, at least intuitively speaking; don't we all closely monitor some patients who are otherwise not critically ill to detect and treat adverse events early and improve the outcome?

Interestingly enough, the group of patients that benefited the most were those who required > 5 days of intensive care. The patients with higher glucose levels and receiving higher insulin dose experienced the high-

est mortality, further suggesting that perhaps sicker patients die regardless of whether they receive the intensive insulin infusion.

How Can We Get Glucose Under Control?

The protocol used to control blood glucose in the Leuven study is shown in Table 1.

There are similar protocols with different desired blood glucose ranges that are being used in cardiac surgery ICUs. The protocol used by Brown et al uses more elaborate scheme to control blood glucose.

How Easy is it to Tightly Control Blood Glucose?

Although the nomogram used in the Leuven study is arguably very simple, I am not sure how easy it is for bedside implementation. A study by Brown et al showed that although an algorithm may improve the blood glucose control, there is still a lot of variability among ICU patients. They used a slightly different protocol, the details of which are available in the article cited. Further attempts are being made to automate the process, where continuous blood glucose monitoring data is sent to a pump with preprogrammed algorithm that has the capacity to be manually altered. Such a technology may make it easier to implement the intensive insulin regimen.

Several obvious cautions are necessary when using an intensive insulin protocol. Whenever feedings are interrupted, there has to be a near-automatic adjustment or stopping rule for insulin infusion. I think it will be interesting to see how much of the time the patient actually stays under the goal blood glucose of 80-110 mg /dL on such a protocol. It would also be interesting to study how much increase in workforce is necessary since it seems that almost every single patient in ICU would be on an insulin infusion via central venous catheter, at least based on the Leuven study.

Conclusion

Stress hyperglycemia is variably defined. By and large, most studies suggest that stress hyperglycemia is a marker of increased morbidity and mortality in critically ill patients. There are limited data to suggest that tight control of blood glucose in normal range in nondiabetic critically ill patients will result in improved outcome. More studies are needed to confirm safety, efficacy and cost of strict glucose control in critically ill patients. ■

Suggested Reading

1. van den Berghe G, et al. Intensive insulin therapy in the critically ill patients. *N Engl J Med*. 2001;345(19): 1359-1367.
2. Martinez-Riquelme AE, Allison SP. Insulin revisited. *Clin Nutr*. 2003;22(1):7-15.
3. Van den Berghe G, et al. Outcome benefit of intensive insulin therapy in the critically ill: Insulin dose versus glycemic control. *Crit Care Med*. 2003;31(2):359-366.
4. Brown G, Dodek P. Intravenous insulin nomogram improves blood glucose control in the critically ill. *Crit Care Med*. 2001;29(9):1714-1719.
5. McCowen KC, et al. Stress-induced hyperglycemia. *Crit Care Clin*. 2001;17(1):107-124.

Table

Protocol for Tight Glucose Control

Test	Blood Glucose	Action
Measure glucose on entry to ICU	> 220 mg/dL	Start insulin 2-4 IU/h
	220-119 mg/dL	Start insulin 1-2 IU/h
	< 110 mg/dL	Do not start insulin but continue BG monitoring every 4 h
Measure glucose every 1-2 h until within normal range	> 140 mg/dL	Increase insulin dose by 1-2 IU/h
	110-140 mg/dL	Increase insulin dose by 0.5-1 IU/h
	Approaching normal range	Adjust insulin dose by 0.1-0.5 IU/h
Measure glucose every 4 h	Approaching normal range	Adjust insulin dose by 0.1-0.5 IU/h
	Normal	Insulin dose unchanged
	Falling rapidly	Reduce insulin dose by half and check more frequently
	60-80 mg/dL	Reduce insulin dose and check BG within 1 h

6. Umpierrez GE, et al. Hyperglycemia: An independent marker of in-hospital mortality in patients with undiagnosed diabetes. *J Clin Endocrinol Metab*. 2002;87(3):978-982.
7. Malmberg K. Prospective randomized study of intensive insulin treatment on long-term survival after acute myocardial infarction in patients with diabetes mellitus. DIGAMI (Diabetes Mellitus, Insulin Glucose Infusion in Acute Myocardial Infarction) Study Group. *BMJ*. 1997;314(7093):1512-1515.

CME / CE Questions

1. **An educational intervention aimed at reducing the incidence of catheter-associated bloodstream infections in the ICUs of a nonteaching, community hospital:**
   a. proved too expensive, so that the hospital administration refused to support it.
   b. was unable to duplicate the positive results obtained in university teaching hospitals.
   c. was actively resisted by the ICU nursing and physician intensivist staffs.
   d. All of the above
   e. None of the above

2. **An educational intervention aimed at reducing the incidence of catheter-associated bloodstream infections in the ICUs of a nonteaching, community hospital:**
   a. decreased the incidence by 57%.
   b. decreased the incidence by 29% .
   c. had no effect on the incidence.
   d. increased the incidence by 29%.
   e. increased the incidence by 57%.

3. **When practices in regard to closed system suctioning (CSS) were examined, findings included which of the following?**
   a. Closed-system suction catheters were changed at 72 hours intervals in all sites.
   b. None of the sites reported using normal saline instillation.
   c. Less than half the sites had a policy for oral care.
   d. The minimal cuff leak technique was used by less than 10% of sites.
   e. Registered nurses accurately identified the correct range for cuff pressures.

4. **To keep endotracheal tube cuff pressure at a level sufficient to prevent micro-aspiration, but below tracheal perfusion pressure, the cuff pressure should be:**
   a. 15-20 mm Hg.
   b. 20-25 mm Hg.
   c. 25-30 mm Hg.
   d. 30-35 mm Hg.
   e. 35-40 mm Hg.

5. **Deliberately culturing the lower respiratory tracts of intubated ICU patients for anaerobic bacteria resulted in:**
   a. recovery of colonizing anaerobic organisms in 2 of 26 patients and clinical pneumonia in 1 of the 2 patients.
   b. recovery of colonizing anaerobic organisms in 6 of 26 patients and clinical pneumonia in 4 of 6 patients.
   c. recovery of colonizing anaerobic organisms in 12 of 26 patients and clinical pneumonia in 7 of 12 patients.
   d. recovery of colonizing anaerobic organisms in 15 of 26 patients and clinical pneumonia in 2 of 5 patients.
   e. recovery of colonizing anaerobic organisms in 22 of 26 patients and clinical pneumonia in 5 of 22 patients.

6. **In the study of anaerobic lower airway colonization by Robert et al, how were the specimens obtained?**
   a. Expectorated sputum
   b. Tracheal aspiration
   c. Protected tracheal aspiration and protected tracheal specimen brush
   d. Bronchoscopic protected specimen brush
   e. Bronchoalveolar lavage

7. **Kitabchi et al classified hyperglycemia as:**
   a. blood glucose levels above 110 mg/ dL.
   b. fasting blood glucose level above 200 mg/dL.
   c. random blood sugar level above 126 mg/dL.
   d. fasting blood glucose level above 126 mg/dL or two or more random blood glucose levels greater than 200 mg/dL.
   e. None of the above

8. **In the Leuven study, an intensive insulin regimen was used to achieve:**
   a. blood glucose level less than 200 mg/dL.
   b. blood glucose level less than 80 mg /dL.
   c. blood glucose level between 80-110 mg/dL.
   d. blood glucose level between 140-200 mg/dL.
   e. None of the above

Answers: 1.(e); 2.(a); 3.(c); 4.(b); 5.(d); 6.(c); 7.(d); 8.(c)

CME / CE Objectives

After reading each issue of *Critical Care Alert*, readers will be able to do the following:

- Identify the particular clinical, legal, or scientific issues related to critical care.
- Describe how those issues affect nurses, health care workers, hospitals, or the health care industry in general.
- Cite solutions to the problems associated with those issues.

In Future Issues: **Are 'Routine' Daily Chest X-Rays Justifiable in ICU Patients?**

CRITICAL CARE Plus

EXPANDING YOUR FOCUS IN INTENSIVE CARE

ARDSNetwork Mechanical Ventilation Trial Still Making Waves

Clinicians adopting study recommendations, but controversy continues

By Julie Crawshaw, Critical Care Plus Editor

THE ARDNSETWORK TRIAL THAT BEGAN IN 1996 (ARMA TRIAL)[1] WAS DESIGNED TO TEST THE VALIDITY OF USING lower tidal volumes in mechanical ventilators was halted because critics who were not a part of the ARDSNetwork argued that the control arm chosen was harmful and unethical.

The study ended in 1999 but the controversy continues today. Early study data indicated that the lower tidal volume was effective. And since that data was released, low tidal volume ventilation has been embraced by clinicians around the world, dramatically changed ICU practice, and improved survival rates in ARDS patients. Yet critics continue to argue that study results can't be correctly interpreted because all that can be concluded is that the low tidal volume arm was better than a harmful control arm.

If you believe the 22% reduction in the death rate of ARDS patient on low tidal volume occurred only because the protocol was measured against something harmful, then it's not very impressive, notes Gordon D. Rubenfeld, MD, of the Division of Pulmonology & Critical Care Medicine at Harborview Medical Center in Seattle.

But Rubenfeld believes it is wrong to say that the control arm strategy used in the study deviated considerably from the standard of care. He says that many doctors use the 12 mL/kg Predicted Body Weight (PBW) tidal volume that served as the study's control arm rather than the 6 mL/kg study results showed improves survival.

Misunderstanding Leads to Criticism

Much of the criticism arose and continues, Rubenfeld says, because many doctors mistakenly believed the 12 mL/kg parameter referenced Measured Body Weight (MBW) which is approximately 20% less than PBW. "It's true that the only thing we know is that 6 mL/kg of predicted body weight is better than 12 mL/kg. We don't know that 6 is better than 4, 7, 8, 9 or 10 mL/kg." Rubenfeld says. "It's also true to say we're never going to know those things because it would take thousands of patients—nobody's going to pay for that."

Rubenfeld says that much work remains before the 6 mL/kg tidal volume is universally accepted. It's a best practices issue, Rubenfeld believes. Nurses and respiratory therapists have problems using 6 mL/kg because patients may appear less comfortable than they do with 12 mL/kg, Caregivers have to get used to a whole new set of laboratory tests because patients tend to drop their oxygen saturation.

Furthermore, some data show that primary physicians recognize ARDS in only about 30% of their patients who have it. "If you don't recognize that a patient has acute lung injury you're not going to use the protocol," Rubenfeld notes.

Two physicians who are not members of the ARDSNetwork complained to the federal Office of Human Research

Protections (OHRP), which in turn conveyed its concerns to the National Heart, Lung and Blood Institute (NHLBI), which in its turn sponsored an ongoing trial in which patients were receiving 6 mL/kg PBW. This trial had certain design characteristics that were similar to the tidal volume trial. The NHLBI voluntarily suspended the trial while the ARDSNetwork investigators studied the issues and prepared responses prior to submitting their responses last June.

Everybody has read the criticisms of the study, Rubenfeld adds, but few in the front lines realize that two independent review boards (IRBs), the first convened by the National Institute of Health and the second by OHRP, reviewed the ARDSNetwork trial and found it to be valid.

"Many practitioners are left with a vague sense that something was wrong with the study, so they continue doing what they've been doing," Rubenfeld says.

Problems with uptake of evidence are hardly unique to critical care, as Rubenfeld points out. But practitioners in other specialties are ahead of critical caregivers in encouraging and reminding practitioners that they need to adhere to the best practices evidence demonstrates. "What's new in critical care is that now we actually have evidence," Rubenfeld says. "Ten years ago we didn't have many clinical trials we could use as evidence—there were lots of evidence in cardiology and oncology—but not in critical care."

In most of those fields thoroughly studied, the gap between evidence-based medicine and practice is lower because specialty societies have pushed for and gotten programs that encourage practitioners to use evidence-based guidelines. Rubenfeld stresses the need for such programs in critical care, adding that this is definitely a challenge for big critical care professional organizations.

Unfortunately, critical care has comparatively few good clinical trials from which to distill best-practices information. "We need to invest in more projects such as the randomized controlled trial in 10 community hospitals we're running here to try and change ventilator behavior at the bedside," Rubenfeld says.

Lack of IRB Information Cited

Patricia El-Hinnawy of the OHRP says her organization found that when reviewing and approving the ARMA trial, the reviewing IRBs failed to receive or request sufficient information to make the required determinations.

El-Hinnawy reports no estimated date for completion of review. "There are some exchanges of information and analyses from the ARDS Net researchers that our office needs to look at before we will consider the case to be closed," she says.

A 15-page letter sent by OHRP to concerned parties last July said that "almost all of the consultants engaged by OHRP opined that risks to subjects participating in the ARMA trial were minimized and reasonable in relation to anticipated benefits to the subjects and the importance of the knowledge that was expected to result."[2]

The letter continued, "OHRP believes, however, that the interests of future human subjects would be served best by further discussion within the scientific and bioethics communities about issues regarding appropriate research design in the absence of a standard of care that have been raised in the context of OHRP's compliance oversight evaluation of the ARMA trial. OHRP encourages such discussions."

Survey of Tidal Volumes Used Preceded Study

According to B. Taylor Thompson, MD, director of the Medical Intensive Care Unit and Medical Director of the ARDSNetwork Clinical Coordinating Center at Massachusetts General Hospital in Boston, ARDSNetwork investigators relied on a survey of ICU practitioners and an analysis of tidal volumes used in clinical care when they chose the study parameters.

Taylor adds that this analysis showed that 10 mL/kg PBW was commonly preferred and used by clinicians, though tidal volumes of 10-15 mL/kg MW had been recommended by experts in the field for many years.

"Accordingly, this tidal volume was a reasonable representation of both usual practice in the early 1990s and the traditionally recommended approach," Taylor says. "We chose PBW, based on height and gender, because height and gender better estimate an individual patient's lung size."

Those clinicians who participated in the trial had used a wide range of tidal volumes prior to enrolling in the trial. "The mean tidal volume was 10.4 mL/kg PBW, which is 1.4 mL/kg lower that our traditional group," Taylor says, "(That's) a very small difference in tidal volume of unclear clinical importance even in retrospect."

He points out that by the time of the tidal volume trial clinicians had already begun moving from traditionally recommended tidal volumes to lower ones, as one consensus recommendation suggested clinicians do. However, this recommendation was not based on sound clinical evidence and it was unclear, if indeed clinicians' practices were indeed changing, that they were

changing in the right direction.

Another explanation for the slightly lower tidal volumes in use at ARDSNetwork sites, as Taylor points out, is that during the trial routine care was influenced by the conduct of the trial. Clinicians at study hospitals had been informed of the study and its rationale. Knowing that researchers were evaluating tidal volumes as low as 6 mL/kg may have influenced clinicians to modify their practice and to choose tidal volumes intermediate between the study groups—a well-known phenomenon called the Hawthorne effect. Thus, as Taylor observes, baseline data in any clinical trial may not be an accurate source of information about usual care prior to a trial.

Earlier Trials Used Lower Volumes

Taylor adds that in two large clinical trials that included ARDS patients during the early 1990s, physicians prescribed tidal volumes of approximately 10.5-11.5 MBW. In the ARDSNetwork trial, MBW exceeded PBW by 20% on average. Assuming that this 20% difference was true in the early 1990s-and Taylor observes there's no reason to think otherwise-then physicians were prescribing tidal volumes of 12.5-13.5 mL/kg PBW in the early 1990s. Taylor adds that in another recent trial MBW exceeded PBW by more than 30%. "If these things were so, then it would seem that the NIH's quarrel with the study is not with improved outcomes associated with using a 6 mL/kg perceived body weight, especially as early data indicated low tidal volume was effective," Taylor says.

"On balance, the ARDS Network trials have withstood unprecedented external review and were found to be soundly designed and important," Taylor says. "We look forward to continuing our trials with the hope that we can provide ICU clinicians with sound clinical evidence to improve the care of critically ill patients around the world."

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References

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High-Tech Beds: Better Outcomes or Needless Expense?

Much of the evidence is negative

SPECIALTY BEDS MARKETED FOR ICU PATIENTS RANGE from simple air-filled mattresses designed for use on ordinary hospital beds to high-tech, electronically controlled rotating or vibrating devices. Specialized beds can become a bone of contention between nurses, to whom bed companies direct their marketing efforts, and physicians, many of whom believe the lion's share of benefits accrue to the manufacturer.

This appears to be especially true of the automated rotational beds that rent for $150-250/d. Though some ICU nurses are convinced that these beds improve outcomes, many physicians consider the evidence base that such beds improve outcomes to be shaky at best.

"My hospital spends an enormous amount of money renting these beds each year, and there are frequent disagreements at the bedside when nurses urge physicians to put their patients on them," says David J. Pierson, MD, professor of medicine at the University of Washington in Seattle. "There is substantial marketing literature but I am not impressed by it."

Study Finds No LRIS Difference

Investigators in a study designed to test the hypothesis that automated rotational therapy reduces the incidence of respiratory complications associated with mechanical ventilation found no significant difference in the incidence of lower respiratory tract inflammatory syndrome (LRIS) in the group using automated rotational beds (17% vs 26%; $P = 0.15$).

This was a prospective, randomized multicenter trial of intubated, mechanically ventilated patients free of respiratory infection. Study subjects used a standard intensive care unit bed or an automated rotational bed that could turn the patient as much as 32° from the horizontal at a rate of 8 times per hour.

Study investigators did find a significantly lower incidence of urinary tract infection (11% vs 27%; $P < 0.05$) in the patients treated with automated rotational beds in this study. But nurses involved in this study noted that eight of the patients using automatically rotated beds became anxious. No other significant differences in the development of other clinical events were observed.

Patients in this study were followed until successful

extubation, death, or development of a LRIS. Other clinically important events (ie, cardiac, urinary, gastrointestinal, neuropsychiatric) were also recorded.[1]

Ventilator-Associated Pneumonia

Another study that evaluated the effect of continuous lateral rotational therapy on the development of ventilator-associated pneumonia in 37 patients requiring long-term mechanical ventilation found significantly lower prevalence of pneumonia (17.6%) as compared with control patients (50%; $P < .05$). Researchers also found that developing pneumonia after entering the study was also significantly delayed for those patients who experienced continuous lateral rotational therapy, 29 ± 8 days vs 12 ± 2 days in controls ($P < .05$). However, unit mortality, total ventilator days, and the number of successful ventilator weanings did not differ significantly between groups.[2]

In other words, in patients requiring long-term ventilator care, continuous lateral rotational therapy reduced the prevalence of pneumonia but did not seem to affect mortality or the period of mechanical ventilation.

Mark Astiz, MD, of the Department of Medicine at New York Medical College, was one of the researchers in this study. Astiz observes that he and fellow researchers elected to do the study because data in other groups of patients indicated that using rotational beds could be associated with reduction in pneumonias.

Patients often develop nonfatal pneumonias that increase both the lengths of hospital stay and time on a ventilator, Astiz notes, adding that his team didn't perceive any difference in outcomes. "Significant reduction in pneumonia didn't really improve overall survival," Astiz says.

Joyce Weisshaar, PNP at Children's Memorial Hospital in Chicago, says her facility elected not to go with automatic rotational therapy because hospital had experienced better success by keeping patients prone. When rotational therapy first came out several years ago a representative of a bed company demonstrated the bed. "Our physicians attended a presentation by a bed company representative but when they looked at the numbers, they found we were having more success proning patients than bed research indicated we could expect," Weisshaar says.

Proning, or positioning patients on their stomachs, increases oxygenation by allowing more space for lungs to expand Weisshaar explains. "We used the rotational bed one time but the patient was too unstable." Weisshaar says the current practice in her hospital is turning patients on to their stomachs once a day for 20 hours.

Weisshaar adds that a current nursing study originating at Boston Children's Hospital is investigating whether proning decreases hospital length of stay and days on a ventilator. Perhaps when that study is completed proning will be the position of choice.

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References

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