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PA Catheter Use and Outcomes in High-Risk Surgical Patients

ABSTRACT & COMMENTARY

PULMONARY ARTERY CATHETERS (PACS) ARE WIDELY USED IN critically ill patients. Proponents of the catheter, introduced into the clinical arena more than 30 years ago, argue that physiologic data provided by the use of the PAC permit clinicians to target treatment and improve patient outcomes. Despite its widespread use, the risks, benefits, and appropriate use of the PAC in specific clinical situations have not been identified. The purpose of this study was to compare therapy guided by a PAC to therapy guided without a PAC among high-risk elderly patients undergoing surgery followed by a stay in the ICU.

The study, conducted over a 9-year period (1990-1999) by the Canadian Critical Care Clinical Trials Group, is the first randomized, controlled trial published that has evaluated the effect of the use of the PAC on mortality and morbidity in "high-risk" surgical patients. Nineteen centers in Canada participated. Patient eligibility criteria are summarized in Table 1. Patients randomized to the standard-care group did not receive a PAC (measurement of central venous pressure with a central line was allowed). Patients randomized to the PAC group had a PAC placed before surgery and treatment was directed to physiologic goals as summarized in Table 2. Clinical and outcome data were collected 24 hours postoperatively, weekly during the ICU stay and hospital stay, and 6 and 12 months postoperatively.

During the 9-year data collection period, 3808 patients were screened and 1994 (52.4%) underwent randomization, with 997 patients in each group (satisfying a *priori* power analysis criteria). In the standard group, 945 patients (94.8%) received planned therapy; 2.4% crossed over to the PAC group. More patients in the PAC group than the standard care group received inotropic agents, vasodilators, antihypertensives, RBC transfusions, and colloids. Goals for CI and DO_2 index were met in 18.6% and 21% of patients at entry and in 79% and 62% of patients, respectively, after surgery.

The baseline characteristics of the patients in both groups were similar in terms of the Goldman Index, vital capacity, forced expiratory volume in the first second, and blood values for hemoglobin,

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Table 1.
Eligibility Criteria

- Age > 60 years
- ASA Class III or IV Risk
- Scheduled for urgent/elective major surgery (abdominal, thoracic, vascular, hip)

bilirubin, and creatinine. There was no difference in median hospital length of stay between the 2 groups (10 days; $P < 0.41$) and no difference in in-hospital mortality (7.7%, 7.8%; $P < 0.93$). There were no differences in morbidity between the 2 groups for acute myocardial infarction, congestive heart failure, dysrhythmias, hepatic or renal insufficiency, catheter-related sepsis, wound infection, pneumonia, or adverse catheter related events. There was a higher incidence of pulmonary embolism in patients in the PAC group (0 events in the standard group vs 8 events [0.8%] in the PAC group; $P < 0.004$). However, thromboprophylaxis was used in 90.9% of the standard care group and in 88.1% in the PAC group ($P < 0.05$). (Sandham JD, et al. *N Engl J Med*. 2003;348:5-14).

Table 2.
Physiologic Goals

Oxygen delivery (DO_2)	550-600 mL/min/m^2
Cardiac index (CI)	3.5-4.5 L/min/m^2
Mean arterial pressure	70 mm Hg
Pulmonary artery wedge pressure	18 mm Hg
Heart rate	< 120 beats/min
Hematocrit	> 27%

COMMENT BY KAREN JOHNSON, PhD, RN

This study provides us with 2 important contributions to the highly debated issue of whether the use of PACs makes a difference in the care of critically ill patients. First, it demonstrated that patients with a PAC did not have a higher mortality than patients who did not have a PAC, as has been previously reported.[1] Secondly, an randomized, clinical trial on the use of PACs can be done in terms of the feasibility of conducting a large multicentered investigation and in terms of physician cooperation. The Canadian Critical Care Clinical Trials Group must be congratulated for pulling this study off!

How should we change our care based on these results? The editorial accompanying this paper states that these findings should affect patient care and that the "routine insertion of PACs perioperatively in high risk surgical patients is not warranted."[2] Time out! This is an inflammatory generalization! Before we change patient care, we need to address some additional questions as a result of this study. Here are just a few. 1) Was this an evaluation of the PAC or just another evaluation of goal-directed therapy? Would more aggressive intra-operative achievement of physiologic goals have made a difference in postoperative outcome? 2) Was everything done to ensure adequate data collection and interpretation of hemodynamic data? 3) Is the ASA Classification System an appropriate and accurate way to stratify surgical patients as "high-risk"? Why did 25% of the Class III patients not even receive a central line? 4) Why did more patients in the standard therapy group than the PAC group develop renal insufficiency? What are the cost implications of this? 5) Almost 1100 patients who met study criteria refused to participate in the study. Physicians did not refer 365 eligible patients. Did these exclusions create a bias in the sample?

Other studies have demonstrated the difficulty with using goal-directed therapy.[3] The goal-directed therapies used in this study were directed at oxygen delivery

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indices only. There were no resuscitation end points, such as mixed venous oxygen saturation, oxygen consumption, oxygen extraction, lactate, base deficit, pH, etc. Was it the PAC or the goal-directed therapy that failed to improve patient outcome in the PAC group? It is difficult to separate the therapy from the tool used to direct the therapy.

The investigators did not indicate that any of the recommendations from the Pulmonary Artery Consensus Statement were incorporated into the data collection process of this study[4] (however, this study was long underway when the recommendations were published in 1997). The reliability and validity of hemodynamic data obtained by the bedside nurse and interpreted by the critical care practitioner were not addressed. What were the training, credentialing, and continuing quality improvement activities that took place in these institutions? It has been recommended that "no study evaluating the use of the PAC can be performed without first controlling for the accuracy of data and skills of the bedside nurse."[5] The usefulness of the PAC cannot be demonstrated without addressing the physiologic and technical variables that influence data collection and interpretation. The "Pulmonary Artery Catheter Continuing Education Program" was specifically developed for multidisciplinary use in addressing these issues (www.pacep.org). Future studies must use this program as credentialing criteria for data collection and interpretation processes. It is imperative that *all* clinicians who use the PAC receive this training.

Why did more patients in the standard therapy group develop renal insufficiency? There were 95 patients (9.8%) in the standard care group and 70 patients (7.4%) in the PAC group who developed this complication. Although this did not achieve statistical significance ($P < 0.07$), it is clinically significant. Renal insufficiency was defined as a "50% increase in creatinine concentration or the need for dialysis in a patient with pre-existing non-dialysis dependent renal failure." Twenty-five more patients in the standard group developed renal insufficiency. If these 25 patients required continuous renal replacement therapy, the cost of treating this complication would be significantly higher in the standard care group than in the PAC group.

This study represents significant progress toward identifying the role of PACs in the diagnosis and management of critically ill patients. More studies like this are needed to help determine the risks and benefits of the PAC and identify appropriate use of the PAC in specific clinical situations. The quest to identify the clinical value of data obtained from PACs continues. ■

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Special Feature

Blood Culture Dilemmas in the ICU

By Charles G. Durbin, Jr., MD

Sepsis and its consequences are common causes of death in the United States.[1] Detection of infection and its proper treatment are essential for survival in all patients, but especially those in the ICU. Indiscriminate use of antibiotics will not improve clinical outcome and will increase risk of resistance and pathogenic overgrowth of fungal species in the GI tract and elsewhere. Cost of care will be adversely affected as well. While these general principles are agreed to, actual diagnostic and treatment approaches to infection and sepsis in the critically ill are not uniform or consistent with these principles. Much of our understanding of infection is derived from caring for hospitalized but not critically ill patients.

The Role of the Clinical Examination

Clinicians suspecting infection in the ambulatory patient "go for the gold" by obtaining information from the most clinically obvious place. A patient with a productive cough will have a sputum specimen sent for culture and perhaps a chest radiograph to rule in or out a lower respiratory tract infection. Symptoms of flank pain or painful urination result in urine cultures with Gram stain or chemical analysis for excessive leukocyte activity in the lower (or upper) urinary tract. Occasionally a patient will present with a fever and no specific organ system or physical symptoms suggestive of a locus of infection. This may lead to blind collection of blood cultures to rule out occult endocarditis or other source of persistent bacteremia as a marker of infection and a (very rare) cause of fever. If the cultures are negative, other causes of fever are considered (ie, occult tumors, vasculitis, venous thrombosis, inflammatory disorders, unusual infectious agents, etc) and the workup continues and expands. Negative cultures have a high negative predictive value, ie, that there is no occult infection or

endocarditis. However, positive blood cultures in these asymptomatic patients create problems.

Blood Cultures

Suggestions for the use and interpretation of blood cultures in noncritically ill patients have been proposed.[2] Large numbers of patients have been studied. These studies indicate that if a positive culture is obtained, there is about a 50% chance that it will be a "false-positive" (contaminant), rather than a "true-positive" culture. On examination of the published data, it appears that a positive blood culture is predictive of infection *only* in a small subset of patients—specifically, those with signs of infection other than fever.[3] The added cost of finding "false-positive" cultures in patients without signs of infection (other than fever) was found to be much more than just the cost of the cultures.

The Table compares the effects on the length of stay and several components of hospital charges (a surrogate for hospital costs) for patients with false-positive blood cultures, compared to those with "true-negative" cultures. These data suggest a 20% increase in unnecessary laboratory charges and a 39% increase in pharmacy charges, mainly from unnecessary intravenous antibiotics. Bates and Lee encourage limiting the use of blood cultures to those patients in which there is a suspicion of infection (such as leukocytosis and clinical symptoms referable to an organ system), and not obtaining a blood culture when fever is the only sign present.

This approach to limiting blood cultures has not been applied widely to hospitalized patients, and frequent "screening" blood cultures are obtained in patients in whom fever is the only sign suggesting infection. This situation continues to create diagnostic problems for clinicians and increases costs for hospital systems and patients. As an extension of these findings in noncritically ill patients, I believe that blood cultures are used in the critically ill. Although there is less published information in the critically ill patient, it seems reasonable to apply a similar diagnostic and treatment approach to critically ill patients.

Sepsis is Not Synonymous With Infection

Severe sepsis, sometimes called SIRS (systemic inflammatory response syndrome) or the systemic inflammatory/anti-inflammatory syndrome, is **the** major problem in the ICU today. This condition is responsible for most ICU-related deaths and is the leading cause of multiple organ failure. Estimates are that more than 800,000 patients develop sepsis and at least 215,000 die from uncontrolled inflammation due to sepsis during critical illness each year in the United States.[1] Enormous energy and dollars are being spent researching and treating this condition. "Surviving Sepsis" is an international campaign spearheaded by the International Sepsis Forum to raise understanding and to reduce mortality from this condition. Information for patients and clinicians is provided at the organization's web sites (www.survivingsepsis.org; www.sepsisforum.org).

The understanding of the basic mechanisms of this disease (or collection of diseases) is evolving, and a recent review suggests that immune suppression and organ "hibernation" may be key elements governing its poor outcome.[4] Outcome from sepsis is not specifically related to the presence of a pathogenic organism in the blood or its antibiotic susceptibility but the degree of shock and organ dysfunction that occurs. Specific organisms and their byproducts seem to be important markers of the severity but not usually the primary precipitating process for sepsis in most ICU patients with this syndrome. Antibiotics are supportive (and essential) but not curative in severe sepsis. Antibiotic coverage should not be direct-

Table.

Increases in Length of Stay and Resource Use are Associated with False-Positive Blood Cultures

Group	Length of stay	Total Charges After Blood Culture	Pharmacy Charges following Blood Culture	Laboratory Charges following Blood Culture
True Negative Blood Cultures (n = 1097)	8 days	$8731.00	$798.00	$1426.00
False Positive Blood Cultures (n = 94)	12.5	$13,116.00	$1456.00	$2057.00

Adapted from: Bates DW, Lee TH. Rapid classification of positive blood cultures. Prospective validation of a multivariate algorithm. *JAMA*. 1992; 267(14):1962-1966.

ed *only* to the organism, which grows from blood cultures, but should be broad enough to cover organisms residing in the intestinal tract and on body surfaces.

With the understanding that sepsis is not synonymous with "infection" I would like to propose a logical way of investigating "infection" in the critically ill. While repeated negative blood cultures (up to 6 sets) are helpful in ruling out continuing bloodstream invasion in the ambulatory (healthy?) patient, positive and negative blood cultures are more problematic in the septic ICU patient.

Bacteremia is Not Sepsis

Many studies have demonstrated that bacteremia is a common occurrence in healthy individuals and not associated with systemic manifestations of sepsis. Even 30 years ago, asymptomatic bacteremia was recognized as occurring during normal clinical interventions. In one study of intubation techniques, 16% of children had positive blood cultures during nasotracheal intubation.[5] In the entire group studied, 65% of children had positive blood cultures during or following dental extractions.[6] No child had any signs of sepsis or developed a perioperative infection, and none received antibiotics despite having pathogenic organisms cultured from their blood. Just manipulating the gums while brushing the teeth results in bacteremia.

The conclusion I would propose is that *bacteremia is a normal occurrence, and thus the presence of a positive culture by itself is not sufficient evidence of sepsis, nor is it a reason to treat with antibiotics.* If blood cultures are drawn from healthy individuals, many will be positive but none are pathologic. The same should be true in the critically ill. Blood culture positivity (asymptomatic bacteremia) must be occurring frequently during routine ICU manipulations and to separate out what is "normal" bacteremia from infection that should be treated is not possible based solely on the organism identified in a single set of blood cultures. If multiple sets of cultures contain the same organism, this probably does represent the need to treat; however, antibiotic treatment should remain broad, and not just directed toward the cultured organism.

Septic Patients May be Bacteremic

When we thought sepsis was "infection," a long, exhaustive search for the source of the infection was the diagnostic mantra. Some clinicians still believe this erroneous idea. Clearly, undrained pus and undiagnosed invasive infections must be rigorously searched for, but the role of obtaining frequent blood cultures in this search is less certain. If random and nonpathogenic bacteremia are assumed to be at least as common in the critically ill as in healthy individuals, positive blood cultures not representing disease would often be found. The remarkably low rate of culture positivity in the critically ill is probably related to the widespread use of broad spectrum antibiotics, suppressing bacterial growth. Using antibiotic-inactivating culture materials and larger amounts of blood per sample increases the positivity only marginally with no improvement in diagnosis. The point is that even a positive blood culture is unlikely to mean the patient is actually "infected" with that particular organism; specific antibiotic treatment directed only against the organism identified is inappropriate for several other reasons.

Bacteremia as a Marker of Severity of Sepsis?

Many studies of sepsis suggest that bacteremia may be an "epi-phenomenon," possibly related to the severity of sepsis but not its cause. In the early studies testing anti-endotoxin (AE) and antitumor necrosis factor (ATNF) antibodies, several things become clear. First, there was no overall survival benefit from the use of these expensive therapies (although several subgroups did appear to show improved outcome). Second, since patients were entered before culture results were available, many culture-negative septic patients were administered the test antibodies. Of the patients entered in these studies, only about 40% subsequently had positive blood cultures. The effect of the trial treatment in these culture-negative patients was not different than in those with positive cultures. The primary determinant of outcome was the degree of shock and organ failure, not whether a blood culture was positive or negative. There also was little relationship of survival to whether "appropriate, specific antibiotic" treatment was given. Patients not receiving appropriate antibiotics for the specific organism that eventually grew in the blood had similar survival to those patients in whom initial antibiotic coverage included the cultured organism. This suggests that the detected bacteremia was not usually pathogenic in septic patients.

Reports from the first human trial of monoclonal antibody, HA-1A (EA), suggested a survival benefit for those patents presenting in shock with positive blood cultures for Gram-negative organisms.[7] However, only 200 of the 534 patients (37%) entered into the study had positive cultures. Of these, 16% had isolated bacteremia without identified infection. When all patients were considered, there was no benefit to receiving HA-1A treatment. In analyzing the treatment and control groups' severity of illness, it became apparent that renal and hepatic failure occurred much more frequently in the control group. This failure of randomization invalidated the conclusions, and the therapy was not consid-

ered effective based on this trial. In a second large trial of HA-1A (EA), 1578 out of 2199 patients had culture-negative septic shock while only 621 (28%) had positive blood cultures.[8] Treatment with HA-1A in this large trial was not effective in either group (blood or other positive culture, or no culture positive) at improving survival. Mortality of patients in the blood culture negative group was slightly worse at 39% than those in the blood culture positive group, 33%. Thus, in this study, bacteremia seemed to confer some survival benefit; it certainly did not correlate with a worsened outcome.

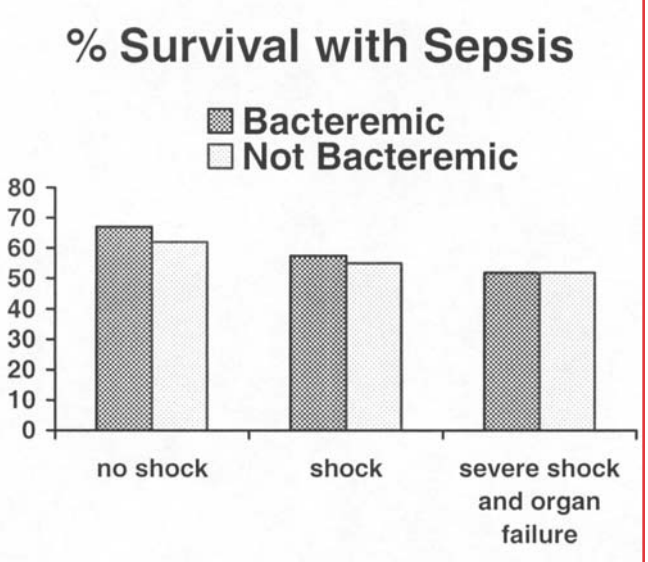
I present these data to suggest that bacteremia is incidental and not pathologic in most patients with sepsis. The determining factor in sepsis survival is the severity of the syndrome. As shown in the Figure (data extracted and combined from 4 studies), survival is reduced as the degree of shock and organ dysfunction increases, not whether cultures are positive.

When to Obtain Blood Cultures in the Critically Ill

The Society of Critical Care Medicine has developed and published Guidelines on fever workup in the critically ill.[9] These Guidelines state: "A new onset of temperature equal to or above 38.3°C is a reasonable trigger for a *clinical assessment, but not necessarily a laboratory (blood cultures)* or radiologic evaluation for infection." I added the italics and comments in parentheses for emphasis and clarification. This is consistent with the recommendations described above for the workup of a noncritically ill hospitalized patient with a fever. These SCCM Guidelines suggest obtaining 2 independent sets of blood cultures if the clinical examination suggests infection within the first 24 hours after a new fever unless there is unequivocal evidence of a noninfectious source of the fever. Repeated blood cultures should be based on the clinical evaluation of the patient, not on persistent or recurrent fevers alone. Cultures of other potential infected sites (such as sputum and urine) are probably more important and significant for guiding therapy than the blood cultures.

Figure.

Outcome in Sepsis According to Whether Blood Cultures were Positive or Negative in 4 Published Studies



Adapted from: Ziegler EJ, et al. *N Engl J Med*. 1991;324(2):429-436; McCloskey RV, et al. *Ann Intern Med*. 1994;121:1-5; Bone RC, et al. *Crit Care Med*. 1995;23(6):994-1006; Reinhart K, et al. *Crit Care Med*. 1996;24(5):733-742.

Broad Spectrum Antibiotics

I have recommended not tailoring the antibiotic coverage to a single organism in the critically ill, especially if the organism is only identified in a blood culture. Antibiotic therapy is supportive in sepsis. Immune system failure (dysfunction) is the basis of sepsis. Barrier function of the gut and mucous membranes fails, resulting in a greater amount of "normal" leak of bacteria from these sources. It seems logical that supportive therapy should be directed against all the organisms usually contained within these locations. This means antibiotic coverage should include Gram-positive, Gram-negative, aerobic, and anaerobic organisms, and possibly fungus as well. The importance of antibiotic treatment increases with the severity of the sepsis.

Guidelines from many organizations suggest that when an identified infection is associated with positive blood cultures for the same organism, treatment should include coverage with 2 antibiotics instead of only 1 (double coverage doctrine). This has the practical effect of maintaining a "broad spectrum" of antibiotic treatment even if 1 specific organism is targeted. If signs of sepsis and septic shock are also present (or the patient fails to improve), then the broadest coverage is recommended despite there being only a single organism identified, for fear of missing an "uncultured" pathogen. While not explicitly stated, the result of this escalating therapy is the same as my recommendation of not narrowing the antibiotic spectrum when positive blood cultures are found in the critically ill.

Central Lines and the Risk of Bloodstream Infections (BSI)

The most important source of nosocomial blood stream infection (BSI) in the critically ill is colonization of a central venous catheters (CVC) leading to BSI. In the setting of a critically ill patient with a CVC, blood cultures have a significant role in diagnosis and therapy.

While some clinicians assume that arterial lines are an important nosocomial source, this does not appear to be true. Likewise, peripheral intravenous lines are unlikely to be sources of "true" BSIs. Careful, aseptic, sterile placement techniques and meticulous line care are essential to reduce this problem. Subcutaneous tunneling of central line catheters should reduce the BSI risk but will increase the incidence of mechanical line complications. The use of elemental silver- and antibiotic-impregnated CVCs is a promising development to reduce this hazard, although risk reduction and cost increase must be balanced. Methods of sterilization without removal of the catheter have been developed to reduce the morbidity of catheter replacement where the replacement is difficult.[10] An emerging risk for BSI may be needle-less connectors, which are mandated by Federal regulation and are almost impossible to sterilize. The use of many of these devices results in contamination and bacterial seeding during the injection process.

Diagnosis of Catheter-Related BSI

Removal and culture of the indwelling catheter is the standard for diagnosis and treatment of catheter colonization. If simultaneous peripheral blood cultures are positive, then catheter-related BSI is likely. If the line is suspected as the source of a fever and it is easy to replace, it should be removed and the tip cultured. The most widely used laboratory technique for the clinical diagnosis of catheter-related infection is the semi-quantitative method, in which the catheter segment is rolled across the surface of an agar plate and colony-forming units (CFU) are counted.[11] Quantitative culture of the catheter segment requires either flushing the segment with broth or sonicating it in broth, followed by serial dilutions and surface plating on blood agar.[12-14] A yield of ‡15 CFU from a catheter, by means of semi-quantitative culture, or a yield of ‡100 CFU from a catheter, with accompanying signs of local or systemic infection, is indicative of catheter-related infection.

In a prospective study that compared the sonication, flush culture, and roll plate methods, the sonication method was 20% more sensitive for the diagnosis of catheter infection than was the roll plate method, and it was > 20% more sensitive than was the method of flushing the individual catheter lumens.[15] If only catheter-related BSI are considered, the sensitivities of the 3 methods are: sonication, 80%; roll plate method, 60%; and flush culture, 40-50%. Specificity could not be determined in this study since all patients had peripheral positive cultures to the organism found on the catheter by 1 or more of the test methods. Differentiation of bacteremia from another source causing catheter colonization rather than a primary CVC infection leading to bacteremia is a difficult problem to sort out.

Quantitative CVC aspiration blood culturing techniques have been developed as an alternative for the diagnosis of catheter-related BSI in patients for whom catheter removal is undesirable because of limited vascular access. Attempts have been made to improve the diagnosis of catheter-related infection by drawing samples for culture through the line and peripheral veins comparing the number of CFU. This technique relies on quantitative culture of paired blood samples, one of which is obtained through the central catheter hub and the other from a peripheral venipuncture site. In most studies, when blood obtained from the CVC yielded a colony count at least 5- to 10-fold greater than that for blood obtained from a peripheral vein, this was predictive of catheter-related BSI.[16] Among tunneled catheters, for which the method is most accurate, a quantitative culture of blood from the CVC that yields at least 100 CFU/mL is considered diagnostic without a companion culture of a peripheral blood sample.[17] Most clinical microbiological laboratories are not capable of performing this type of analysis.

A new method, which correlates well with quantitative blood cultures, makes use of continuous blood culture monitoring for positivity (eg, radiometric methods) and compares the differential time to positivity for qualitative cultures of blood samples drawn from the CVC and a peripheral vein. When studied with tunneled catheters, this method has offered accuracy comparable to that of quantitative cultures of blood samples and has had greater cost-effectiveness.[18,19] In a study of differential time to positivity, a definite diagnosis of catheter-related bacteremia could be made in 16 of the 17 patients who had a positive result of culture of a blood sample from the CVC at least 2 h earlier than they had a positive result of a peripheral blood culture; the overall sensitivity was 91% and specificity was 94%.[16] Most hospitals do not have quantitative blood culture methodologies, but many will be able to use differential time to positivity for diagnosis.

Putting the Picture Together

Bacteremia is common in critically ill patients but is infrequently the only sign of infection. The sepsis syndrome may be initiated by a specific infection, but this is not invariably true. Treatment of the septic patient involves hemodynamic and specific organ support and antibiotic coverage. Specific organ and fluid cultures should be used to confirm infections in patients with symptoms suggesting pneumonia, urinary tract infection, etc. Because bacteremia is common and not pathological in "healthy" as

well as ICU patients, blood cultures should be reserved for those patients in whom bacteremia would be considered pathologic (eg, suspected CVC infection, suspected endocarditis, etc). Negative cultures may be reassuring, but positive blood cultures may be misleading. If repeated cultures are positive for the same organism, a primary focus of infection should be sought and antibiotic coverage should include, but not be limited to, the identified organism.

In the absence of other findings of specific risk factors, fever is not an indication to obtain blood cultures in the ICU patient. If blood cultures are obtained, persistent fever or recurrent fever alone is not an indication for repeated blood cultures. To avoid problems in interpretation, strict protocols must be used for skin preparation, sampling size, and handling of specimens for blood cultures. CVCs are a particular risk of nosocomial infection in the ICU. Strict adherence to sterile placement and handling must be used. Identifying CVC colonization and infection is difficult but a low threshold for line removal is important. The rate of CVC colonization and related BSI are quality markers of an ICU system of care and may become a mandatory required measure for all ICUs in the future. ■

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CME / CE Questions

1. **Which of the following is true about patients who had pulmonary artery catheters, compared to patients in whom PA catheters were not used, in the study of Sandham et al?**
   a. They had higher ICU and overall hospital mortality.
   b. They had longer ICU stays.
   c. They had a higher incidence of acute myocardial infarction.
   d. All of the above
   e. None of the above

2. **Which of the following is true about patients who had pulmonary artery catheters, compared to patients in whom PA catheters were not used, in the study of Sandham et al?**
   a. They required fewer blood transfusions.
   b. Hemodynamic goals in the PA group were met less than half the time.
   c. They had a lower incidence of pulmonary embolism during the study.
   d. They received more inotropic agents and vasodilators.
   e. A larger proportion of them were younger than 60 years old.

3. **Bacteremia:**
   a. is never a benign condition in healthy or critically ill patients.
   b. suggests active endocarditis and must be treated with 4-6 weeks of culture-specific antibiotics.
   c. is a common occurrence in healthy and ill patients.
   d. is only significant when a known pathogen is seen.
   e. is of no significance unless there is a known source of infection.

4. **A patient with a central venous catheter and a fever:**
   a. must have at least 6 peripheral blood cultures drawn prior to starting antibiotic therapy.
   b. should only have quantitative cultures drawn from the distal port.
   c. should have cultures of the skin entrance hold and drawn from the distal port.
   d. should have the catheter rmoved and the tip and subcutaneous porting cultured.
   e. should have empiric fungal coverage started if the line has been in for more than 7 days.

Answers: 1. (e); 2. (d); 3. (c); 4. (d)

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: **Should Critically Ill Patients Receive Erythropoietin?**

CRITICAL CARE Plus

EXPANDING YOUR FOCUS IN INTENSIVE CARE

Assessing BIS Monitoring in Critical Care

Use increasing, but study questions efficacy for ICUs

By Julie Crawshaw, Critical Care Plus Editor

BISPECTRAL INDEX (BIS) MONITORING HAS RECEIVED A GENERALLY FAVORABLE RECEPTION SINCE ITS FORmal introduction at the American Association of Critical Care Nurses National Teaching Institute and Critical Care Exposition last spring. BIS technology works through a sensor placed on the patient's forehead that gathers information from electrical brain activity and translates it into a single number from 100 (indicating an awake patient) to 0 (indicating the absence of brain electrical activity) to describe the patient's level of consciousness.

Dai Wai Olson, BSN, CCRN staff nurse at Duke University Hospital in Durham, NC, says that BIS has its limitations, as does any tool. "The more that we learn about using BIS, the more benefits and drawbacks we see," Olson says. "We're finding that by knowing its limitations we're using it on more appropriate patients and getting the information we need. Patients' needs for sedation vary, but the BIS gives us an objective guideline."

Over- and under-sedation of patients is a widely recognized challenge in ICUs, where sedation assessment has been guided primarily by vital signs or subjective sedation assessment scales. Olson says his hospital began BIS monitoring about four years ago as part of a research protocol for anesthesiologists. As more research occurred, Duke incorporated BIS into its critical care practice. The hospital has documented significant cost savings when BIS is used to guide sedation management.

Scores Vary, Appear Unrelated to Patient Age

Olson acknowledges that it's still pretty early in research life to define the perfect BIS score and says that patient age does not appear to be a factor in BIS score variance. "We haven't identified any factors for variance, and I don't think I've read any research that has tried," he says. " Patients of different ages require different amounts of sedation, but that doesn't give us a goal. There are some patients we want to be more deeply sedated, so we go for a lower BIS goal. Generally, we shoot for between 60 and 70, and we think that's where we'll stay for most of our patients."

Olson notes that under-or-over-sedation can create events that negatively affect nearly every system in the body, ultimately increasing the risk of complications, time on the ventilator, and length of stay in the ICU. Monitoring with the BIS, he says, can be difficult because of space limitations due to the presence of other, more important monitors that makes the monitor useless in patients with certain brain injuries.

"We're a neural ICU, so when we get someone with a bilateral frontal injury, the area you need to monitor is mush," he says.

BIS monitoring has been used for monitoring anesthesia effects in the operating room for a number of years. BIS manufacturer Aspect Medical Systems says the technology has been used to assess more than five million patients and has been the subject of more than 900 published articles and abstracts. The company further claims that BIS is "currently in use in the ICUs of more than 60 percent of the best-ranked hospitals with operating rooms in the U.S."

Olson says he doubts that the manufacturer initially realized that ICUs were a potential market, adding that his hospital was using BIS before Aspect began marketing it for critical care.

Study Challenges BIS Usefulness in ICUs

However, a study reported in *Critical Care Medicine* warns, "there are no published, peer-reviewed studies of the level of consciousness in critically ill patients demonstrating a strong correlation between clinical assessment and objective values measured by the BIS monitor."[1] The study population included a general ICU heterogeneous population older than 18 years of age with a decreased level of consciousness in the surgical and medical ICUs of the Tufts-New England Medical Center in Boston. Most of the patients studied were receiving pharmacologic sedation; some had sustained concurrent metabolic encephalopathies or cerebral injury from underlying disease. Patients' severity of illness was described using the Acute Physiology and Chronic Health Evaluation (APACHE II) Severity of Disease Classification.

That study notes that BIS has been "tuned through successive iterations of software revisions to correlate with the degree of sedation in patients undergoing anesthesia for short periods of time in the operating room." The monitor was not designed using data collected from critically ill patients sedated for prolonged periods of time in an ICU setting.

Additionally, investigators in referenced studies observed that the BIS scores did not correlate with clinical assessment in 12 of the 29 patients studied. Yet the investigators concluded that the "BIS provided a reliable index of neurologic status in the awake, unsedated critically ill patient".

The study also found that patient skeletal muscle movement produced inconsistent BIS readings and concluded that "the inconsistent and sometimes inaccurate measurements provided by the BIS device dampen the hopes of caregivers who are in search of an objective measurement of the level of consciousness in sedated, critically ill patients."

For more information contact Dai Wai Olson at (919) 681-4241, and Aspect Medical Systems at (888) 247-4633. ■

Reference

1. Nasraway S, et al. How reliable is the bispectral index in critically ill patients? A prospective, comparative, single-blinded observer study. *Crit Care Med*. 2002;30(7):1483-1487.

CDC Halts Frequent Ventilator Breathing Circuit Changes

In guidance that should spell millions of dollars saved for the nation's hospitals, the Centers for Disease Control and Prevention (CDC) is calling a halt to routine changes of ventilator breathing circuits. The move comes in new draft recommendations to prevent hospital-acquired pneumonia, one of the deadliest and most frequent nosocomial infections.

Frequent, routine circuit changes originally were designed to protect patients from aspirating the condensate that collects in the vent tubing down into their lungs. Steadily emerging science now has established a contrary view: frequent handling and changing the vent tubing may actually put patients at greater risk of exposure to bacterial pathogens that lead to ventilator-associated pneumonia (VAP). Thus, the CDC dropped its 1996 recommendation to change the breathing circuits "no more frequently than 48 hours." The new recommendation is "do not change routinely, on the basis of duration of use, the ventilator circuit (ie, ventilator tubing and exhalation valve, and the attached humidifier) that is in use on an individual patient. Rather, change the circuit when it is visibly soiled or mechanically malfunctioning."[1]

Substantial Savings Projected

"If this is implemented by the majority of hospitals, it will literally save hundreds of thousands of dollars, if not millions of dollars," says Robert Garcia, MT, CIC, assistant director of infection control at Brookdale University Hospital and Medical Center in Brooklyn, NY. "Because of the advances in ventilators, we do not need to do a lot of things that we used to do—the changing of these circuits and all of that. The more you manipulate the devices, the greater the risk that the person is going to aspirate something."

Having already extended change-out times from two to seven days, Garcia is ready to adopt the new recommended policy and simply leave circuits in place. "I'm 100% sure that is the way we are going to go," he says.

Another key change in the ventilator guidance is a similar recommendation regarding in-line suction catheters used with closed-systems suction. The CDC draft now advises that clinicians only change the in-line suction catheter when it malfunctions or becomes visibly soiled. "That is a major change in recommendations," Garcia says. "In the last guideline, they didn't

even address the issue of when to change the closed-suction devices."

Some manufacturers recommend changing out the in-line suction catheter every 24 hours, but there has been little evidence to support the necessity of the practice, he adds. "These things cost about $10 a day," Garcia says. "Changing it every single day—think about a patient who is averaging seven days [on a ventilator]. Now, I only change it when it is visibly soiled or we have mechanical failure. That is a major cost reduction. I mean, I run 60-65 vents on any given day."

Weighing the Evidence

In making the new ventilator circuit recommendations, the CDC cited studies demonstrating the safety and cost-effectiveness of extending change-out intervals. In one study, investigators found no increase in the incidence of VAP and a savings of more than $110,000 per year in materials and personnel salaries when breathing circuits were changed every seven days rather than every 48 hours.[2] Similar studies have found that when circuits are not changed for the duration of use by a patient, the risk of a patient developing pneumonia [eight (29%) of 28] is very similar to the risk when circuits were changed every 48 hours [11 (31%) of 35].[3] Finally, a recent study showed that patients whose breathing circuits were left unchanged indefinitely (unless observed to be grossly contaminated) for the duration of mechanical ventilation did not have a higher risk of acquiring pneumonia compared with those whose breathing circuits were changed routinely every seven days.[4]

"These findings indicate that the previous CDC recommendation to change ventilator circuits routinely on the basis of duration of use should be changed to one that is based on visual and/or known contamination of the circuit," the draft guidelines state. "This change in recommendation is expected to result in large savings in device use and personnel time for US health care facilities."

Naturally, the level of savings will depend on current practice at individual hospitals, many of which already have cut tube-changing frequency as more patient safety data emerged.

"There is definitely a cost savings from the standpoint of not changing your circuits," says Michael Byet, BA, RRT, technical specialist for the respiratory care department at University Arizona Medical Center in Tucson. "There are some hospitals back East that are doing one-week change-outs, and so forth. We have been at two weeks for a long time," he says. "We initially went to one week, and then extended it because we weren't seeing any increase in infection rates at all. Our VAPs actually went down." Indeed, it was during a multifaceted effort to lower VAPs that another ICP took a look at her hospital's change-out policies.

A significant finding was that the ventilator circuit was considered to have three components, with tubing changed every seven days and the heat moisture exchanger (HME) and in-line suction catheter changed daily (though not necessarily at the same time), explains Margaret Bertrand, RN, BSN, NMCC, an ICP at the Veterans Affairs Medical Center in Lexington, KY. The VAP rate rose to 41 infections per 1,000 patient days under the old policy.

A Systems Breakdown

"I did some unobtrusive observation, watching people, and there was frequent breaking of the systems," she says. "You would have nurses breaking the system to suction and then respiratory would come along 15 or 20 minutes later and break the system again to do a treatment or change out an HME."

As a result, the policy was changed. The three components of the ventilator circuit are managed as a single closed unit, which is changed only if obvious soilage or mechanical malfunction occurs. Such soilage is typically blood or vomit, so the need for change-out is obvious, Bertrand says. "Only respiratory therapists can change the ventilator tubing. They set it up initially, and they check it every four hours. Nursing no longer breaks the system to change out suction catheters. In the case of an emergency, of course, they would [take measures]. We're still seeing good results. For the first and second quarter of 2002, we only had one vent pneumonia [infection]."

Other interventions—including staff education and an emphasis on waterless hand washing—also contributed to the rate reduction. Having anticipated the CDC's national recommendation, Bertrand has no doubt such policies are the wave of the future. "Back in the mid-1970s or so, there was the same problem with urinary tract infections, and then they went to the closed system for the Foley," she says. "That did help. I think this is the same kind of thing—that constant breaking of the system and messing with it essentially colonizes the tubing and exposes the patient to whatever bacteria [workers] have on their hands."

Looking only at equipment, Bertrand estimates the new policy is saving her hospital $16,000 a year. Other savings that can be calculated in are personnel time and —if VAP rates go down—the prevention of nosocomial pneumonia. According to one study, VAP infections prolong hospitalizations and increase costs

by an average of $17,677 per patient.[5] "Since we reduced our vent pneumonias so dramatically over time, of course, we are saving patient days of care," she says. "For our patients, we were adding 10 to 20 days [per infection], most of it spent in the ICU. So that is really expensive." ■

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