Ventilator-associated pneumonia (VAP), which is usually defined as an infection occurring greater than 48 hours after hospital admission in a patient requiring mechanical ventilation, is an entity that should be viewed as a subcategory of health-care-associated pneumonia, which includes any patient who was hospitalized in an acute care hospital for 2 or more days within 90 days of the infection; resided in a nursing home or long-term care facility; received recent antibiotic therapy, chemotherapy, or wound care within the past 30 days of the current infection; or attended a hospital or hemodialysis clinic. VAP is the most frequent intensive-care-unit (ICU)-acquired infection among patients receiving mechanical ventilation. In contrast to infections of other frequently involved organs (eg, urinary tract and skin), for which mortality is low, the mortality rate for VAP ranges from 20% to 50% and can reach 70% in some specific settings or when lung infection is caused by high-risk pathogens and/or when initial antibiotic therapy is inappropriate. Although the attributable mortality rate for VAP is still debated, it has been shown that these infections prolong both the duration of ventilation and the duration of ICU stay. These prolonged hospitalizations underscore the considerable financial burden imposed by the development of VAP. The causes of VAP are many and may vary by hospital, patient population, and type of ICU, emphasizing the need for timely, local surveillance data. In many cases infection is caused by multiple-drug-resistant pathogens. Risk factors for such resistant microorganisms are the duration of mechanical ventilation, prior antibiotic treatment, and contact with the health care system. Preventive measures should be guided with regard to a full understanding of pathogenesis and epidemiology. Because respiratory-tract colonization of ICU patients is generally very complex, corresponding to a mix of self-colonization and cross-transmission, only a multifaceted and multidisciplinary program can be effective. Antimicrobial therapy of patients with VAP should follow a 2-stage process. The first stage involves administering broad-spectrum antibiotics to avoid inappropriate treatment in patients with true bacterial pneumonia. The second stage focuses on trying to achieve this objective without overusing and abusing antibiotics, combining a number of different steps, such as stopping therapy in patients with a low probability of the disease, streamlining treatment once the etiologic agent is known, switching to monotherapy after days 3–5, and shortening duration of therapy to 7–8 days, as dictated by the patient’s clinical response to therapy and information about the bacteriology of the infection. Key words: ventilator-associated pneumonia, health care-associated pneumonia, epidemiology, multiple-drug-resistant microorganisms, prevention, fiberoptic bronchoscopy, bronchoalveolar lavage, quantitative culture techniques, antimicrobial therapy. [Respir Care 2005;50(7):975–983. © 2005 Daedalus Enterprises]
Introduction

A few months ago, when I was invited to serve as the summarizer for the Respiratory Care Journal Conference on ventilator-associated pneumonia (VAP), my gut feeling was to refuse, due to the overwhelming complexity of the task. Probably it would have been a very wise and prudent decision, yet the topic has been near and dear to my heart for more than 20 years, since my fellowship in Bichat hospital in Paris. Furthermore, this is such an honor that it was impossible to refuse.

Despite an enormous amount of research and many official statements, the definition, diagnosis, treatment, and prevention of VAP remain controversial. In this summary I will not only present what I took to be the key messages of the conference but also indicate some of the ways we could do a better job for our patients, translating new understandings into improved patient care, based on a synthesis of the proceedings, along with personal observations and editorial remarks.

Definition and Epidemiology of VAP

Four presentations, by Drs Kollef, Maki, Park, and MacIntyre, were devoted to the definition and epidemiology of the disease. First of all, Marin Kollef pointed out that VAP, which is usually defined as an infection occurring > 48 hours after hospital admission in a patient requiring mechanical ventilation, is in fact an entity that should be viewed as a subcategory of health care-associated pneumonia (HCAP). This point may have very important therapeutic implications, since early-onset VAP, as defined by a prior duration of mechanical ventilation of less than 5 days, can occur in patients with previous contact with the health care system, and thus may need therapy for multiple-drug-resistant bacterial pathogens. HCAP includes any patient who was hospitalized in an acute care hospital for 2 or more days within 90 days of the infection; resided in a nursing home or long-term care facility; received recent antibiotic therapy, chemotherapy, or wound care within the past 30 days of the current infection; or attended a hospital or hemodialysis clinic.1,2 As underlined by Kollef, the microorganisms responsible for infection in such settings are exactly the same as those observed in late-onset lung infection, and that type of information should be taken into account for selecting initial antimicrobial treatment.

Why VAP Is Important

Ventilator-associated pneumonia is the most frequent intensive care unit (ICU)-acquired infection among patients receiving mechanical ventilation.2,3 In contrast to infections of other frequently involved organs (eg, urinary tract and skin), for which mortality is low, ranging from 1% to 4%, the mortality rate for VAP, defined as pneumonia occurring > 48 hours after endotracheal intubation and mechanical ventilation initiation, ranges from 20% to 50% and can reach 70% in some specific settings or when lung infection is caused by high-risk pathogens.2,4 Although the attributable mortality rate for VAP is still debated, it has been shown that these infections prolong both the duration of ventilation and the duration of ICU stay.2,3,5 These prolonged hospitalizations underscore the considerable financial burden imposed by the development of VAP. However, a precise and universal evaluation of such overcosts is very difficult, as underlined by Joseph Solomkin at the end of the conference. Cost analysis is, indeed, dependent on a wide variety of factors, which differ from one country to another, including health care system, organization of the hospital and the ICU, the possibility of patients being treated by private practitioners, cost of antibiotics, and confounding factors such as the responsible pathogen or the severity of the underlying disease. Recently, the extra hospital charges attributed to nosocomial pneumonia occurring in a large data set of United States ICU patients were evaluated to be > $40,000 United States dollars.6 Interestingly, approximately 50% of all antibiotics prescribed in an ICU are administered for respiratory-tract infections.6 Because several studies have shown that appropriate antimicrobial treatment of patients with VAP significantly improves outcome, more rapid identification of infected patients and accurate selection of antimicrobial agents represent important clinical goals.2,3 All these data were discussed in depth by Drs Kollef, Maki, and Rello and underscore why VAP can so terribly impact patients in the ICU and why its diagnosis, prevention, and treatment are so important.

Pathogenesis and Prevention

Dennis Maki then talked about the pathogenesis and prevention of VAP in the ICU. Very importantly, he reminded us that preventive measures should be guided with regard to a full understanding of pathogenesis and epidemiology. Thus, we need to be able to precisely define the route of respiratory-tract colonization by Gram-negative bacilli (GNB) in that setting, distinguishing between pa-
tients in whom colonization originates from endogenous sources, such as the intestinal tract, and those in whom colonization originates from exogenous sources, such as contaminated equipment or other patients colonized with multi-resistant bugs. The intestines are considered the most important endogenous source of microorganisms reaching the respiratory tract via the gastropulmonary route, via colonization of the skin, or via transiently colonized hands of health care workers during tending. The potential importance of exogenous sources of GNB (eg, contaminated equipment) has been repeatedly demonstrated during outbreaks of infections with those organisms. In addition, colonized patients serve as continuous exogenous sources of microorganisms from which other patients can be colonized via cross-acquisition. Knowledge about the relative importance of exogenous and endogenous routes of colonization is essential in order to design targeted strategies for infection prevention. Obviously, preventive strategies will be different when either of the 2 routes is dominant. Unfortunately, the relative importance of both routes of colonization in endemic settings has seldom been determined.

For Pseudomonas aeruginosa the epidemiology of colonization is generally characterized by polyclonality, with most patients being colonized with unique genotypes of P. aeruginosa. Respiratory-tract colonization is frequently present on admission, and, when it is acquired in the ICU, the intestinal tract seems to be more important as a source than are cross-acquisition and acquisition from the gastric reservoir. Therefore, increasing compliance with infection-control measures, as well as attempts to interrupt intestinal or gastric colonization, are unlikely to decrease the endemic level of P. aeruginosa colonization. Antibiotics providing P. aeruginosa with a selective growth advantage are the most important risk factors for acquisition of respiratory-tract colonization. In such circumstances, a regimen that prevents colonization of the upper respiratory tract would be much more effective in preventing VAP. Such an approach has been tested twice, and in both studies oropharyngeal decontamination with nonabsorbable antiseptics significantly reduced the incidence of VAP.

The epidemiology of nosocomial respiratory-tract colonization and/or infection with other GNB and even P. aeruginosa is, however, often much more complex because of the coexistence of epidemic cases with unrelated sporadic cases caused by different strains, underlining the necessity to use molecular typing to improve the detection of microepidemics amenable to early control. For example, in a study of 20 patients with nosocomially acquired Acinetobacter baumannii infection, ribotyping of the responsible isolates showed that an epidemic of 11 cases was coexisting with 17 sporadic cases characterized by the diversity of their banding patterns. Using case-control analyses, the only independent risk factor for epidemic Acinetobacter infection was to have undergone a surgical procedure in the emergency operating room before being admitted to the ICU, and the only risk factor for sporadic Acinetobacter infection was a prior receipt of fluoroquinolone. Without the use of sophisticated molecular techniques to clearly identify which exact microorganism was responsible for each infection, the epidemiology of this outbreak would have been impossible to determine and, therefore, efficacious control measures difficult to implement.

Neil MacIntyre then reviewed the relationship between ventilator-induced lung injury and VAP; that is, can lung-protective management strategy increase the rate of VAP or not? The recent National Institutes of Health ARDS [acute respiratory distress syndrome] Network randomized trial demonstrated that, in patients with acute lung injury or ARDS, ventilation with a tidal volume of 6 mL/kg of predicted body weight reduced mortality to 31%, compared with a mortality rate of 40% in patients treated with a tidal volume of 12 mL/kg. Organ-failure-free days also were significantly improved. Although there are several potential reasons for some clinicians not adopting the 6 mL/kg ventilation strategy, one possibility is that some physicians are concerned that use of the protocol will necessitate an increase in the need for supportive therapies, including sedation and neuromuscular blockade, and/or will increase the total amount of fixed atelectasis. These potential effects are of particular concern, since prolonged sedation can complicate assessment of neurologic dysfunction, can increase utilization of unnecessary diagnostic studies, and may lead to delayed extubation and worse clinical outcomes. Similarly, an increased use of neuromuscular blocking agents could be complicated by prolonged paralysis or diffuse atrophic myopathy, particularly in the setting of administration of corticosteroids, thus increasing the risk for VAP. In fact, as demonstrated in a subgroup analysis of the ARDS Network trial, when compared with a tidal volume of 12 mL/kg predicted body weight, ventilation with a protocol of 6 mL/kg was not associated with adverse effects on hemodynamics or an increased need for sedation and neuromuscular blockade. Therefore, concerns regarding adverse effects of treatment with the 6 mL/kg predicted body weight tidal volume protocol on supportive care requirements should not preclude its use in patients with acute lung injury or ARDS.

Microbiology of VAP

David Park then talked about the microbiology of VAP, discussing 3 major points:

1. The causes of VAP are many and may vary by hospital, patient population, and type of ICU, emphasizing the need for timely, local surveillance data.
2. Infection is caused by multiple-drug-resistant pathogens in many cases.

3. Resistant microorganisms can usually be predicted by the duration of mechanical ventilation, the length of stay before the onset of VAP, and other risk factors such as prior antibiotic treatment and contact with the health care system.

*Legionella* species, anaerobes, fungi, and even viruses should be mentioned as potential causative agents, but are not considered to be common in the context of pneumonia acquired during mechanical ventilation. However, several of these causative agents may be more common, and potentially underreported because of difficulties involved with the diagnostic techniques used to identify them, including anaerobic bacteria and viruses.\(^{21,22}\) By examining currently available data, the clinical importance of anaerobes in the pathogenesis and outcome of VAP remains unclear, except as etiologic agents in patients with necrotizing pneumonia, lung abscess, or pleuropulmonary infections.\(^{23}\) Isolation of fungi, most frequently *Candida* species, at substantial concentrations poses interpretative problems. Invasive disease has been reported in VAP, but more frequently yeasts are isolated from respiratory-tract specimens in the apparent absence of disease. One prospective study examined the relevance of isolating *Candida* species from 25 non-neutropenic patients who had been mechanically ventilated for at least 72 hours.\(^{24}\) Just after death, multiple culture and biopsy specimens were obtained with bronchoscopic techniques. Although 10 patients had at least one biopsy specimen positive for *Candida* species, only 2 had evidence of invasive pneumonia as demonstrated by histologic examination. Many of the endotracheal aspirates, protected-specimen-brush specimens, and bronchoalveolar lavage specimens also yielded positive cultures for *Candida* species, sometimes in high concentrations, but they did not contribute to diagnosing invasive disease. Based on these data and other studies,\(^ {25}\) the use of the commonly available respiratory sampling methods (bronchoscopic or nonbronchoscopic) in mechanically ventilated patients appears insufficient for the diagnosis of *Candida* pneumonia. At present, the only sure method to establish that *Candida* is the primary lung pathogen is to demonstrate yeast or pseudohyphae in a lung biopsy. Probably, a lot of drugs active against *Candida* are prescribed in the ICU without any benefit for patients, physicians misinterpreting the presence of *Candida* in respiratory secretions as being the etiologic agent of pneumonia.

The incidence of VAP caused by viruses is also low in immunocompetent hosts. Outbreaks of VAP and HCAP due to viruses such as influenza A and B, parainfluenza, adenovirus, measles, and respiratory syncytial virus have, however, been reported and are usually seasonal. Influenza is transmitted directly from person to person when infected persons sneeze, cough, or talk, and is highly contagious. The use of influenza vaccine, along with prophylaxis and early anti-viral therapy of at-risk health care workers dramatically reduces spread of influenza within the hospital and health care facilities and should be proposed to all health care workers working in the ICU, since influenza infection could have dramatic consequences in patients requiring mechanical ventilation. Herpes simplex virus is occasionally detected in the lower respiratory tract of ICU patients, but its clinical importance in such situations remains unclear.\(^ {22}\) In most patients the herpes virus is probably only a bystander, but in some cases, for example in patients with ARDS, it could be responsible for tracheobronchitis and/or bronchopneumonia and leads to clinical deterioration.

**Recommendations for VAP Prevention: A Personal Recipe**

Certainly, no conference on how to do the best for patients in the ICU could be held without a serious and in-depth discussion on how to prevent VAP. I was very impressed by the work done by Richard Branson, Dennis Maki, Dean Hess, Jordi Rello, and Richard Kallet; they reviewed all the literature concerning modifiable risk factors and respiratory care for the prevention of VAP and presented a very detailed and comprehensive discussion of each potential prophylactic measure. I would like to encourage everybody interested in this issue to carefully read their articles.

Because respiratory-tract colonization of ICU patients is generally very complex, corresponding to a mix of self-colonization and cross-transmission, only a multifaceted and multidisciplinary program can be effective. The efficiency of such a program, based on a bundle of 14 preventive measures that should be taken simultaneously, was nicely demonstrated by Zack et al in a pre-intervention and post-intervention observational study conducted in 5 ICUs in Barnes-Jewish Hospital.\(^ {26}\) Following implementation of the education module, the rate of VAP decreased from 12.6 per 1,000 ventilator days in the 12 months before the intervention, to 5.7 per 1,000 ventilator days—a decrease of 58% (p < 0.001). The estimated cost savings secondary to the decreased rate of VAP for the 12 months following the intervention were between $425,606 and $4.05 million.

My personal recipe is summarized in Table 1 and includes 12 specific measures. I would like to emphasize some of them. First of all, a large number of studies show that overcrowding, understaffing, or a misbalance between work load and resources are important determinants of nosocomial infections and cross-transmission of microorganisms in the hospital.\(^ {27-29}\) Importantly, not only the number of staff but also the level of their training affect outcomes. The causal pathway between understaffing and infection is complex, and factors might include lack of
CONFERENCE SUMMARY: VENTILATOR-ASSOCIATED PNEUMONIA

Table 1. ICU Policy for the Prevention of Ventilator-Associated Pneumonia: A Personal Recipe

1. Assure adequate intensive care unit staffing levels.27–29
2. Immunize health care workers for influenza.1
3. Implement hand hygiene with alcohol rubs.1,30,31
4. Adopt an antibiotic policy restricting the prescription of broad-spectrum agents and useless antibiotics by implementing strict guidelines, avoiding treating patients without bacterial infection, using narrow-spectrum antibiotics whenever possible, and reducing the duration of treatment.32–34
5. Follow a restrictive transfusion trigger policy.35
6. Reduce as much as possible the duration of mechanical ventilation (a major risk factor for ventilator-associated pneumonia), using:
   - Improved methods of sedation and avoidance of paralytic agents36
   - Protocols to facilitate and accelerate weaning37,38
   - Intensive insulin therapy, with tight control of blood glucose level39
   - Noninvasive mechanical ventilation whenever possible40
7. Avoid nasal insertion of endotracheal and gastric tubes to minimize the risk of nosocomial sinusitis.41
8. Maintain endotracheal tube cuff pressure above 20 cm H2O, to prevent leakage of bacteria around the cuff into the lower respiratory tract.42
9. Reintubate promptly patients who would inexorably fail extubation.43
10. Keep patients in the semirecumbent position, especially in case of enteral nutrition.44
11. Provide adequate oral hygiene with an antiseptic such as chlorhexidine.45
12. Use a heat-and-moisture exchanger or heated-wire circuit instead of a conventional active humidifier to prevent formation of contaminated tubing condensates and their inadvertent flushing into the lower airways.46

Adoption of an antibiotic policy restricting the prescription of broad-spectrum agents and useless antibiotics is of major importance. Several studies clearly demonstrated that the use of antibiotics in the hospital setting was associated with an increased risk of nosocomial pneumonia and selection of resistant pathogens.47–50 Better utilization of antibiotics in the ICU can be achieved by implementing strict guidelines, avoiding treating patients without bacterial infection, using narrow-spectrum antibiotics whenever possible, and reducing the duration of treatment.32,33 On the same line, transfusion of red blood cells and other allogenic blood products should follow a strict restricted transfusion trigger policy, since multiple studies have identified exposure to allogenic blood products as a risk factor for postoperative infection and pneumonia.35,51

Finally, some very simple, safe, inexpensive, and logical measures, including avoiding nasal insertion of endotracheal and gastric tubes;41 maintaining the endotracheal tube cuff pressure above 20 cm H2O to prevent leakage of bacteria around the cuff into the lower respiratory tract;42 prompt reintubation of patients who would inexorably fail extubation;43 keeping patients in the semirecumbent position, especially in case of enteral nutrition;44 removal of tubing condensate;46 and providing adequate oral hygiene with an antiseptic, such as chlorhexidine,45 may have tremendous impact on the frequency of VAP in mechanically ventilated patients.1,2

Diagnosis and Treatment

Drs Niederman, Park, Rello, Solomkin, and I then talked about the diagnosis and management of VAP—2 very controversial topics. We all, however, agree that the major...
goals of any management strategy of patients with true VAP are early, appropriate antibiotics in adequate doses, while avoiding excessive antibiotics and the emergence of multiple-drug-resistant strains.2,3 The only way to do that is to follow 3 steps:

1. To obtain a lower-respiratory-tract sample for culture (quantitative or semiquantitative) and microscopy before introduction of new antibiotics.

2. To immediately start empiric antimicrobial treatment, unless there are both a negative microscopy and no signs of severe sepsis.

3. To re-evaluate treatment on day 2 or 3, based on microbiologic cultures results and clinical outcome.

Very importantly also, ICU physicians should understand the differences between an appropriate treatment and an adequate treatment. Appropriate is matching antibiotic susceptibilities to the antibiotic used. To achieve adequate therapy it is necessary to use not only the correct antibiotic, but also the optimal dose and the correct route of administration (oral, intravenous, or aerosol) to assure that the antibiotic penetrates to the site of infection, and that combination therapy is used if necessary. Many antibiotics in the ICU are incorrectly used, being administered at too low doses, promoting the emergence of resistant strains and decreasing their potential efficacy.

Based on this background, antimicrobial treatment of patients with VAP could be outlined in 6 steps, as summarized in Table 2. The first one is starting treatment using broad-spectrum antibiotics. Because of the emergence of multiresistant GNB, such as Pseudomonas aeruginosa and/or extended-spectrum beta-lactamase-producing Klebsiella pneumoniae in many institutions, and the increasing role played by Gram-positive bacteria such as methicillin-resistant Staphylococcus aureus (MRSA), empirical treatment with broad-spectrum antibiotics is justified in most patients with a clinical suspicion of HCAP.3,4 The choice of agents should be based on local patterns of antimicrobial susceptibility, and anticipated adverse effects, and should also take into account which therapies patients have recently received (within the past 2 weeks), striving not to repeat the same antimicrobial class, if possible.59 Having a current and frequently-updated knowledge of local bacteriologic patterns can increase the likelihood that appropriate initial antibiotic treatment will be prescribed.60 Only patients with early-onset infection and no specific risk factors, such as prolonged duration of hospitalization, admission from a health care-related facility, and recent prolonged antibiotic therapy, can be treated with a narrow-spectrum drug, such as a nonsupendomonal third-generation cephalosporin.2

Because clinical signs of infection are nonspecific and can be caused by any condition associated with an inflammatory response, many more patients than necessary are initially treated with antibiotics. Thus, it is important to use serial clinical evaluations and microbiologic data to re-evaluate therapy after 48–72 hours, in order to be able to stop therapy if infection becomes unlikely. To reach this objective, all diagnostic strategies that are designed for managing patients with a clinical VAP suspicion should make explicit the decision tree they utilize to identify patients with a low probability of infection and thus to stop therapy when infection appears improbable.

For many patients with VAP, including those with late-onset infection, therapy can be narrowed once the results of respiratory tract and blood cultures become available, because an anticipated organism (such as P. aeruginosa, Acinetobacter species, or MRSA) was not recovered or because the organism isolated is sensitive to a less-broad-spectrum antibiotic than used in the initial regimen. For example, vancomycin and linezolid should be stopped if no MRSA is identified, unless the patient is allergic to beta-lactams and has developed an infection caused by a Gram-positive microorganism. Very-broad-spectrum agents, such as carbapenems, piperacillin-tazobactam, and/or cefepime should also be restricted to patients with infection caused by pathogens only susceptible to these agents.

The commonly cited reason to use combination therapy is to achieve synergy in the therapy of P. aeruginosa or other difficult-to-treat GNB. However, synergy has been clearly documented to be valuable only in vitro and in patients with neutropenia61 or bacteremic infection,62,63 which is uncommon in VAP.3 A recent meta-analysis has evaluated all prospective randomized trials of beta-lactam monotherapy compared to beta-lactam-aminoglycoside combination regimens in patients with sepsis, of which at least 1,200 of the reported 7,586 patients had either HCAP or VAP.56 In this evaluation, clinical failure rate was similar with combination therapy, and there was no advantage in the therapy of P. aeruginosa infections, compared to monotherapy. In addition, combination therapy did not prevent the emergence of resistance during therapy, but did lead to a significantly higher rate of nephrotoxicity. Based on these data, therapy could be switched to monotherapy in most patients after 3 or 5 days, provided that initial therapy was appropriate, clinical course appears favorable, and that microbiological data do not point to a very difficult-to-treat microorganism, with a very high in vitro minimal inhibitory concentration, as can be observed with some nonfermenting GNB.

Efforts to reduce the duration of therapy for VAP are justified by studies of the natural history of the response to therapy. Dennesen et al demonstrated that when VAP was adequately treated, significant improvements were observed for all clinical variables, generally within the first 6 days after the start of antibiotics.64 The consequence of prolonged therapy to 14 days or more was newly acquired colonization, especially with P. aeruginosa and Enterobac-
teriaceae, generally during the second week of therapy. These data support the premise that most patients with VAP who receive appropriate antimicrobial therapy have a good clinical response within the first 6 days.64–66 Prolonged therapy simply leads to colonization with antibiotic-resistant bacteria, which may precede a recurrent episode of VAP. A recent multicenter, randomized controlled trial in a large series of 413 patients with microbiologically-proven VAP demonstrated that patients who received appropriate, initial empiric therapy for 8 days had similar outcomes to patients who received therapy for 15 days.34 A trend to greater rates of relapse for short-duration therapy was seen if the etiologic agent was P. aeruginosa or Acinetobacter species, but clinical outcomes were exactly the same. These results were recently confirmed by 2 other studies, including a prospective, randomized trial of 290 patients evaluating an antibiotic discontinuation policy.58,67

### REFERENCES


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**Summary**

This conference brought together a diverse and stimulating group of investigators and clinicians with broad expertise and a dedication to improve the care of ICU patients who require mechanical ventilation and are exposed to the risk of developing VAP. I believe it succeeded in its goals and that the documents developed from it, as well as the recently published guidelines endorsed by the American Thoracic Society and the Infectious Diseases Society of America,2 will prove valuable to clinicians who deal with VAP and to their patients who suffer from this disease. Persistently high mortality rates for pneumonia in the ICU argue, however, for the continued reassessment of our current therapeutic modalities and design of better protocols. More active and less toxic antibacterial agents are still needed, especially for some problematic pathogens, such as multiresistant nonfermenting GNB and MRSA.

The conference co-chairs and the American Respiratory Care Foundation have done a superb job in facilitating the process of this conference, and it has been an honor and a privilege for me—as well as a challenge—to bring it to a conclusion.

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**Table 2. Proposed Strategy for Conducting Antimicrobial Therapy in Patients With VAP**

<table>
<thead>
<tr>
<th>Proposed Strategy</th>
<th>Rationale</th>
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</thead>
<tbody>
<tr>
<td>Step 1: Start therapy using broad-spectrum antibiotics</td>
<td>Because of the emergence of multiresistant Gram-negative bacteria, such as <em>Pseudomonas aeruginosa</em> and extended-spectrum beta-lactamase-producing Gram-negative bacteria in many institutions, and the increasing role played by methicillin-resistant <em>Staphylococcus aureus</em>, empirical treatment with broad-spectrum antibiotics is justified in most patients with a clinical suspicion of VAP.</td>
</tr>
<tr>
<td>Step 2: Stop therapy if the diagnosis of infection becomes unlikely</td>
<td>Because clinical signs of infection are nonspecific and can be caused by any condition associated with an inflammatory response, many more patients than necessary are initially treated with antibiotics.</td>
</tr>
<tr>
<td>Step 3: Use narrower-spectrum drugs once the agent of infection is identified</td>
<td>For many patients with VAP, including those with late-onset infection, therapy can be narrowed once the results of respiratory tract and blood cultures become available, because an anticipated organism (such as <em>Pseudomonas aeruginosa</em>, <em>Acinetobacter</em> species, or methicillin-resistant <em>Staphylococcus aureus</em>) was not recovered or because the organism isolated is sensitive to a less-broad-spectrum antibiotic than used in the initial regimen.</td>
</tr>
<tr>
<td>Step 4: Use pharmacokinetic-pharmacodynamic data to optimize treatment</td>
<td>Clinical and bacteriologic outcomes can be improved by optimizing the therapeutic regimen according to pharmacokinetic-pharmacodynamic properties of the agent(s) selected for treatment.</td>
</tr>
<tr>
<td>Step 5: Switch to monotherapy on days 3–5</td>
<td>There are no clinical benefits to using a regimen combining 2 antibiotics after days 3–5, provided that initial therapy was appropriate, clinical course appears favorable, and that microbiological data do not point to a very-difficult-to-treat microorganism.</td>
</tr>
<tr>
<td>Step 6: Shorten the duration of therapy</td>
<td>Reducing duration of therapy in patients with VAP has led to good outcomes with less antibiotic use. Prolonged therapy simply leads to colonization with antibiotic-resistant bacteria, which may precede a recurrent episode of VAP.</td>
</tr>
</tbody>
</table>

VAP = ventilator-associated pneumonia
CONFERENCE SUMMARY: VENTILATOR-ASSOCIATED PNEUMONIA