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# PREVENTION AND DIAGNOSIS OF VENTILATOR ASSOCIATED PNEUMONIA

## SUMMARY

Best practices for the prevention of ventilator-associated pneumonia (VAP) are centered on developing an effective multidisciplinary “ventilator bundle”. There is emerging evidence that modified endotracheal tubes may be effective in reducing the incidence of VAP. Bronchoalveolar lavage (BAL) is the most accurate method for quantitatively diagnosing the presence of VAP. BAL facilitates appropriate antibiotic use and this benefit often outweighs the additional cost of BAL and the small risk of this invasive procedure. Other less accurate methods of diagnosing VAP may lead to the overuse of antibiotics.

## RECOMMENDATIONS

- **Level 1**
  - **None**
- **Level 2**
  - **Endotracheal tubes with subglottic suctioning devices reduce the incidence of VAP.**
  - **Multidisciplinary ventilator bundles are effective at reducing the incidence of VAP.**
  - **Early, broad-spectrum antimicrobial coverage should be instituted in patients clinically suspected of having VAP.**
  - **Cultures should be obtained in a timely fashion and antibiotic coverage adjusted based upon culture results.**
- **Level 3**
  - **Quantitative culture is the diagnostic method of choice in the evaluation of fever in mechanically ventilated patients and should be performed when there is clinical suspicion of VAP.**
  - **Traditional tracheal aspirate (TA) cultures should not be used to diagnose VAP in mechanically ventilated patients.**
  - **BAL cultures growing more than 100,000 ( $10^5$ ) colony forming units (cfu)/ml indicate a positive culture for pneumonia.**
  - **Mini-bronchoalveolar lavage (Mini-BAL) cultures growing more than 10,000 ( $10^4$ ) colony forming units (cfu)/ml indicate a positive culture for pneumonia.**
  - **Patients with a Clinical Pulmonary Infection Score (CPIS)  $\geq 6$  should undergo either BAL or Mini-BAL.**
  - **Early tracheostomy does not reduce the incidence VAP.**
  - **Silver-coated endotracheal tubes may reduce the incidence of VAP.**
  - **Probiotics may reduce the incidence of VAP.**

## EVIDENCE DEFINITIONS

- **Class I:** Prospective randomized controlled trial.
- **Class II:** Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies.
- **Class III:** Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion.
- **Technology assessment:** A technology study which does not lend itself to classification in the above-mentioned format. Devices are evaluated in terms of their accuracy, reliability, therapeutic potential, or cost effectiveness.

## LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

## INTRODUCTION

Ventilator-associated pneumonia (VAP) is the most widespread infection encountered in the intensive care unit (ICU) and is associated with significant morbidity, mortality and cost (1). Ten to 20 percent of patients mechanically ventilated for greater than 48 hours will develop VAP, increasing mortality two-fold (1). Timely, appropriate antibiotic therapy improves patient survival in the presence of infection. Such treatment, however, can foster antibiotic resistance and incur the associated risks of antibiotic therapy itself.

Much effort has been placed towards the prevention of VAP and there is evidence that prevention strategies are more effective than treatment strategies (2). Prevention strategies are centered on disruption of the development of a biofilm on the endotracheal tube and interruption of microaspiration of oropharyngeal secretions (3). Questions currently being addressed in the medical community include the use of the “ventilator bundle”, the implementation of early tracheostomy, and the benefit of endotracheal tube modifications.

Diagnosis of clinically suspected VAP may be clinical or microbiological. Commonly used clinical VAP criteria include the presence of a new or progressive pulmonary infiltrate on chest radiograph, fever (greater than 38.3°C), leukocytosis or leukopenia, or purulent tracheobronchial secretions. These findings are non-specific and can lead to over-diagnosing VAP, which may lead to inappropriate use of antibiotics. The commonly utilized methods for microbiological diagnosis are highlighted below.

**Tracheal Aspirate (TA):** As the least invasive method, this technique does not require specialized training or equipment. The practitioner suctions the upper airway through a sterile catheter and collects the sputum specimen. As the catheter is inserted blindly, organisms from the biofilm coating the endotracheal or tracheostomy tube may contaminate the culture results obtained. The technique is sensitive, but not specific (sensitivity 38-100% and specificity 14-100%) (8). Quantitative cultures are rarely performed on these samples (4).

**Bronchoalveolar Lavage (BAL):** A fiberoptic bronchoscope is directed to the area of concern within the lung, which is flushed with sterile fluid. The fluid and specimen it carries with it are then suctioned, collected and cultured. BAL may be both diagnostic and therapeutic as mucous plugs and excessive secretions may be subsequently aspirated during the same procedure. Quantitative cultures are usually obtained. The large volume of the specimen makes it useful for detecting non-bacterial pathogens. Sensitivity ranges from 42-93% and specificity from 45-100% (8). Bronchoscopy carries a procedural risk of hypoxia. (4).

**“Mini-BAL” or Non-Bronchoscopic Bronchoalveolar Lavage:** A specialized catheter is inserted into the endotracheal tube. A plug or telescoping catheter system protects the end of the catheter from contamination during insertion. The catheter is advanced approximately 30 cm and the inner cannula is then gently advanced until it meets resistance. Thirty mL of sterile saline is injected and suctioned. This is repeated a second time and the combined aspirate sent for culture. Semi-quantitative or quantitative cultures are usually performed. Sensitivity and specificity are similar to BAL (sensitivity 63-100% and specificity 66-96%) (4,8).

**Protected Brush Specimens (PBS):** A specialized catheter containing a brush is either blindly advanced until gentle resistance is met or inserted during bronchoscopy through the forceps port. When the area to be sampled is visualized, the brush is pushed through a plug and a sample obtained by gentle scraping. The brush is retracted, the catheter or bronchoscope is removed, and a quantitative culture is obtained. Because the sample is low volume, it is not appropriate for detection of non-bacterial pathogens. Results are less sensitive, but more specific than BAL (sensitivity 33-100% and specificity 50-100%) (4,8).

## LITERATURE REVIEW

### ***Clinical outcomes when invasive vs. non-invasive methods are utilized for the diagnosis of VAP***

In a large, multicenter study, patients who had been in the ICU for at least 4 days and were suspected of having VAP were randomized to either BAL with quantitative culture or TA with qualitative culture (5). Both groups received the same empiric antibiotics, which were subsequently tailored to appropriate monotherapy or double-drug coverage by a second randomization if an organism was identified. There were no significant differences between the groups in terms of 28-day mortality, targeted antibiotic therapy, days alive without antibiotics, maximum organ dysfunction scores, length of stay in the ICU or length of stay in the hospital. The authors attribute the lack of difference primarily to the early and standardized empiric antibiotic therapy given to both groups. This study concluded that similar outcomes and use of antibiotics result whether the diagnosis of VAP is made by TA or BAL (Class I). Of note, the study population had a low prevalence of *MRSA* and *Pseudomonas spp.* and so may not be applicable in populations with a high incidence of these infections. In a commentary regarding this study, Fagon et al. express several concerns (6). They reiterate that the relative lack of “high-risk” pathogens in the patients studied makes it difficult to extrapolate these results to many ICUs. They note that many patients received antibiotics within 3 days prior to randomization and that this might particularly interfere with quantitative culture results. A relatively high rate of inappropriate initial therapy was reported in both groups (11% of BAL patients and 10.5% of TA patients). This may be related to a concurrent randomization to dual or monotherapy among these patients and, though it occurred evenly between the groups, may obfuscate the results of the study as a whole. Finally, targeted therapy was achieved in only 74.2% of BAL patients and 74.6 % of TA patients by day 6. This makes the true benefit of the techniques in allowing early de-escalation or targeted therapy difficult to accurately assess.

In another prospective trial, data were collected on all infectious complications in mechanically ventilated burn/trauma patients for the calendar year 2001 (7). Sixty-eight patients clinically suspected of having VAP based on clinical findings (fever, leukocytosis greater than 10,000 mm<sup>3</sup>, purulent sputum, new infiltrate on chest radiograph or increased oxygen requirements) were further evaluated for VAP. In the initial 37 patients, this was done by sputum culture and Gram’s stain of a specimen obtained by the respiratory therapist using an in-line suction catheter (TA). In the subsequent 29 patients, cultures were obtained first as described above and immediately following by BAL. BAL was done by the trauma attending physician or by a surgical resident. All patients were started on empiric antibiotics after cultures were obtained and these were adjusted at the discretion of the attending physician. Initial empiric antibiotic coverage did not differ between the two groups. There were no statistical differences in Injury Severity Score, number of patients correctly treated with empiric antibiotics, hospital length of stay, ventilator days, rate of recurrent pneumonias, antibiotic or respiratory/ventilator costs, or mortality between the groups. There was a trend towards a shorter time before initial treatment in the BAL group, but this was not statistically significant (Class I).

A meta-analysis was performed including four randomized, controlled trials from 1998 to 2000 that compared non-invasive to invasive methods of VAP diagnosis in terms of antibiotic management and overall mortality (9). Together, the studies included 628 patients. Invasive specimens were obtained by BAL and PSB or BAL alone. The overall quality of these studies was rated as moderate and they found clinical and statistical heterogeneity among the trials. Ninety-three percent of all patients received early, appropriate antibiotic therapy. Invasive testing did not alter mortality (Odds ratio 0.89, 95% confidence interval 0.56–1.41), but did lead to tailoring of antibiotic therapy (Odds ratio for change in antibiotic management after invasive sampling, 2.85, 95% confidence interval 1.45–5.59). The authors also reviewed five prospective, observational studies that included 635 patients. This analysis supported the data showing antibiotic alterations resulted from invasive diagnostic techniques in more than half of the patients (pooled estimate for rate of alteration in antibiotic prescription, 50.3%, 95% confidence interval 35.9–64.6%). The authors conclude that invasive techniques are useful in adjusting antibiotic therapy; however, this does not lead to a difference in mortality (Class II).

Mini-BAL has been found to have some practical advantages over BAL in that it can be performed by a trained respiratory therapist and may decrease costs without significantly affecting the diagnostic sensitivity and specificity. In a prospective study by Marik et al (10) comparing mini-BAL and blind PBS (b-PSB) to diagnose VAP in medical and surgical intensive care patients, sequential b-PSB followed by

mini-BAL was performed by trained respiratory therapists. One hundred and ninety paired specimens were obtained from 175 patients. The diagnostic agreement between the two techniques was 90%. In 6 episodes, mini-BAL was negative and b-PSB was positive. In 13 episodes, b-PSB was negative and mini-BAL was positive. The authors conclude that both PSB and mini-BAL can be performed safely by respiratory therapists. Neither diagnostic method was clearly superior (Class II). For a discussion of cost, see below.

### ***The quantitative culture threshold for the diagnosis of VAP***

The number of colony forming units (cfu) that determines a positive culture varies depending upon the technique by which it was obtained. The cutoffs listed below have been determined based on the volume sampled and a desired sensitivity and specificity:

- For TA, a threshold of more than 1,000,000 cfu/ml ( $10^6$ ) is accepted as positive (2).
- For BAL, thresholds ranging between 1,000 ( $10^3$ ) and 100,000 cfu/mL ( $10^5$ ) have been reported (8); however, a value of 100,000 cfu ( $10^5$ ) is gaining clinical acceptance.
- For Mini-BAL a threshold of more than 10,000 cfu/ml ( $10^4$ ) is considered positive (2).
- For PBS, a threshold of more than 1000 cfu/ml ( $10^3$ ) is considered positive (2).

A prospective study was performed to identify the optimal BAL threshold (11). Two hundred fifty-seven BALs were performed in 168 patients. Subdiagnostic quantities of bacteria ( $\geq 100$ , but  $< 10,000$  cfu/mL) were seen in 98 BALs. Of these, only 16 episodes (16%) of VAP with the same organism were seen later during hospitalization. At a threshold of  $\geq 10,000$  cfu/mL, 4 of 28 patients (14%) went on to develop pneumonia. A similar pattern was seen at diagnostic thresholds of  $\geq 1000$  cfu/mL (10 of 72 [14%]) and  $\geq 100$  cfu/mL. The authors conclude that a threshold of  $\geq 100,000$  cfu/mL ( $10^5$ ) for VAP diagnosis carries a low false-negative rate. At least 80% of patients who would have been treated had a threshold of  $\geq 10,000$  cfu/mL been used recovered without treatment and thus would have undergone unnecessary antibiotic exposure. A similar pattern is seen at all lower thresholds (Class II).

In a prospective trauma database study, BAL culture results over a 46-month period were reviewed (12). A false negative BAL was defined as any patient with  $< 100,000$  cfu/mL who then developed VAP with a culture of  $> 100,000$  cfu/mL with the same organism within seven days. The authors found 43 episodes of VAP with a false negative rate of 3%. The data were then reviewed using 10,000 cfu/mL as a diagnostic threshold. They found 106 cases of VAP with a false negative rate of 9%. The authors conclude that with a change in the diagnostic threshold from 100,000 cfu/mL to 10,000 cfu/mL, there are minimal gains in sensitivity, but large drops in specificity and positive predictive value. This might lead to over treatment of some patients and thus 100,000 cfu/mL ( $10^5$ ) is the appropriate clinical diagnostic threshold (Class II).

### ***Use of BAL results to tailor antibiotics***

A 2007 study by Muller et al. found that repeating BAL to monitor success of treatment in cases of VAP may reduce the duration of antibiotic use (13). The duration of antibiotic in the control arm of the trial was dependent on physician discretion and averaged  $16.7 \pm 7.4$  days. The other group was managed with a BAL clinical pathway that utilized BAL on day 4 after initiation of adequate antibiotic therapy. If BAL quantitative cultures grew  $< 10,000$  cfu/mL, the antibiotics were discontinued. The mean antibiotic use was  $9.8 \pm 3.8$  days. There were no differences in pneumonia relapse, ventilator-free ICU days, ICU-free hospital days or mortality (Class I). While this study demonstrated a significant reduction in antibiotic use, which may help to decrease resistance over the long term, their mean days of antibiotic use in the control group was considerably longer than the 8-10 day course that is gaining acceptance (9). Further studies are needed to determine the role of BAL as a guide to antibiotic duration.

In a large, multicenter trial, the use of BAL to determine antibiotic therapy did not result in significant differences in antibiotics administered or days alive without antibiotics (5). As described above, this may be related to the early and standardized empiric antibiotic therapy initially given to both groups.

In the meta-analysis discussed above, BAL did lead to tailoring of antibiotic therapy (odds ratio for change in antibiotic management after invasive sampling, 2.85, 95% confidence interval 1.45–5.59) (9). In three of the four trials that reported antibiotic changes, 20.8% of all patients undergoing BAL and 12.8% of the

non-invasively managed patients had initial inadequate antibiotic therapy that was then adjusted. However, this difference was not statistically significant (Odds ratio 1.96 95% CI 0.91-4.20). The fourth study reported antibiotic-free days and found that invasive testing significantly increased the number of antibiotic free days. Unfortunately, none of the reports consistently describe the reasons for antibiotic changes. The authors conclude that invasive techniques may be used to adjust antibiotic therapy; however, there is no difference in mortality (Class II).

### **Economic Analysis**

In a prospective study, patient charges associated with BAL and quantitative cultures were compared to those of TA (14). Over 14 months, the study enrolled 107 trauma patients based on clinical suspicion of pneumonia (at least 3 of fever > 101 F or < 96 F, leukocytosis >10,000 or immature forms > 10%, purulent sputum, new or worsened infiltrate on chest X-ray). In each case, a TA, PBS and BAL specimen were obtained in that order. One hundred thirty-six sets of cultures were obtained during the study period. Patients were then started on empiric antibiotics of ceftazidime and vancomycin. Antibiotics were tailored according to TA results as cultures returned. The incidence of nosocomial pneumonia by each method was TA (73%), PSB (34%), BAL (25%). Charges were calculated to include the overall charges associated with a diagnosis of nosocomial pneumonia. Based on a 14 day course of antibiotics, the charges associated with diagnosis by TA was \$302,830. Charges associated with PSB were 58% of that and those for BAL were 43%. The authors conclude that the charges incurred by the initial BAL may be offset by the antibiotic savings associated with a lower rate of diagnosis of VAP.

An interesting thought experiment by Ost et al. (15) compared the theoretic costs and benefits of empiric treatment alone, TA, mini-BAL, BAL, and BAL with PSB. They constructed a decision tree for the diagnosis and treatment of VAP and created a hypothetical cohort of immunocompetent patients in the intensive care unit, intubated for 7 days, with evidence of late-onset VAP and an estimated mortality rate of 20% for use in a decision analysis model. The initial decision was whether to do a diagnostic test immediately. The second decision was how many initial antibiotics to give. Two separate aspects of cost were considered: financial cost and antibiotics used. Effectiveness was measured in terms of hospital survival. A decision analysis model that examined 16 strategies in the management of VAP was constructed. Initial coverage with three antibiotics was better than expectant management or one or two antibiotic approaches, leading to both improved survival (54% vs. 66%) and decreased cost (\$55,447 vs. \$41,483 per survivor). Testing with mini-BAL did not improve survival, but did decrease costs (\$41,483 vs. \$39,967) and antibiotic use (63 vs. 39 antibiotic days per survivor). From the perspective of minimizing cost, minimizing antibiotic use, and maximizing survival, the best strategy was three antibiotics with mini-BAL (Class III).

### **Use of a “Ventilator Bundle”**

The use of the ventilator bundle has been adopted by many institutions because it has been shown to reduce the incidence of VAP. A recent multicenter, prospective study from Scotland showed that when the use of a ventilator bundle was reliably adopted, the prevalence of VAP decreased (16) (Class II).

As an example, one validated protocol for prevention of ventilator-acquired pneumonia includes the following (17):

1. Hand washing / hand sanitizing as often as possible
2. Chlorhexidine oral rinse prior to intubation, and then q12 hours on an 0900 and 2100 schedule
3. Oral care with swabs q2-q3 hour
4. Head of bed elevated 30-45 degrees on all patients at all times unless contraindicated
5. Extubate as early as possible
6. Tube feedings to be turned off when placing patients supine, unless a documented post-pyloric feeding tube is present
7. Endotracheal tape changed every 48 hours
8. Minimal use of saline lavage
9. Changing ventilator tubing only when soiled
10. Effective staff communication strategies

Another study from 2005, which highlighted the collaborative approach in adopting a bundle and documenting VAP incidence, demonstrated significant reduction in VAP. 35 intensive care units adopted a focused program for bundle implementation and maintained accountable documentation regarding bundle measures and VAP rates. Within the units, the rate of VAP decreased 44.5%. The conclusion of the study highlighted the development of healthy teamwork that is necessary to improve reliability and improve clinical goals (18).

In 2011, a smaller study was performed that observed pneumonia in ventilated patients before and after a “bundle” approach was adopted. The study saw a VAP rate of 32/100 decrease to 12/1000 after the bundle was initiated ( $p < 0.001$ ) (19). The observed rate of MRSA was also decreased (10% to 3.6%;  $p < 0.001$ ). One of the flaws of the study was a lower than expected adoption of the bundle (70% compliance). The highest adopted interventions were raising the head of the bed and using chlorhexidine gel (95-100% compliance). The lowest compliance was the wake and wean schedule, which saw only 70% compliance (Class II).

### **Adjuncts to Ventilator Bundles**

In addition to bundles, additional techniques for lowering the incidence of VAP have been studied. These measures include the use of silver impregnated endotracheal tubes (ETT), variable cuff design, subglottic suction devices, and pharmacologic interventions including probiotic use and statin use. Some of the more thoroughly studied methods are highlighted below.

In 2015, a meta-analysis of three randomized controlled trials involving 2081 patients demonstrated that the use of silver-coated ETT reduced the risk for developing VAP from 6.7% to 3.5% within 10 days of intubation. The quality of evidence was low in all three studies and larger trials are needed over a longer period of time (20).

In 2015, a randomized controlled trial studied the effects of subglottic suctioning devices included with endotracheal tubes (21). The study included 252 adult patients that were intubated with an endotracheal tube allowing subglottic secretion drainage. The patients were randomized to either undergo suctioning (Group 1; 170 patients) or not (Group 2; 182 patients). During ventilation, microbiologically confirmed VAP occurred in 15 patients (8.8%) of group 1 and 32 patients (17.6%) of group 2 ( $p = 0.018$ ). In terms of ventilator days, VAP rates were 9.6/1000 ventilator days and 19.8/1000 ventilator days, respectively ( $p = 0.0076$ ). Neither length of ICU stay nor mortality differed between groups. The total number of antibiotic days was 1,696 in group 1, representing 61.6% of the 2,754 ICU days, and 1,965 in group 2, representing 68.5% of the 2,868 ICU days ( $p < 0.0001$ ). The authors concluded that subglottic secretion drainage resulted in a significant reduction of VAP. The ETT-SSD was also associated with decreased antibiotic use (Class I).

In 2016, a selection of trauma patients was studied comparing the rate of VAP in patients intubated with ETT allowing subglottic secretion drainage (ETT-SSD) (22). The study included 1,135 patients who were matched according to multiple injury criteria. In the matched cohorts, the ETT-SSD group had a lower VAP rate of 5.7/1000 ventilator days versus 9.3/1000 ventilator days in the standard ETT group ( $p = 0.03$ ). The ETT-SSD group had decreased ventilator days (12 days vs. 14 days;  $p = 0.04$ ). The ETT-SSD group also had a decreased length of stay (13 days vs. 16 days;  $p = 0.003$ ). The study concluded by stating the routine use of ETT-SSD is recommended despite the increased cost of \$10-\$30 per tube (Class III).

In 2014, in a Cochrane Database Systematic Review, the authors studied the effectiveness and safety of probiotics in reducing VAP. 1083 patients from eight randomized control trials were included. The probiotics used were various Lactobacillus species, Streptococcus thermophilus, and Bifidobacterium longum. All trials indicated a reduction in VAP, but the evidence was of low quality. Thus, the use of probiotics to prevent the development of VAP cannot be concluded as either efficacious or safe. Further high quality studies are needed (23).

Regarding the use of tracheostomy, in 2010 clinicians sought to investigate the effect of early tracheostomy on the incidence of VAP (24). The study had 209 patients randomized to an early tracheostomy group (6-8 days post intubation) and 210 patients randomized to a late group (13-15 days

post intubation). The early group subsequently had a 14% incidence of VAP and the late tracheostomy group had a 21% incidence of VAP (P=0.07). This study did not meet statistical significance (Class I).

A systematic review and meta-analysis of randomized controlled trials was completed in 2011 by Wang et al. that sought to compare important clinical outcomes between critically ill patients receiving early or late tracheostomy (25). Seven trials were identified with a total of 1044 patients. They concluded that early tracheostomy did not reduce VAP (RR 0.94; 95% CI, 0.77-1.15) (Class I).

Contrary to these studies, but retrospective in nature, a study in 2015 looked at 106 matched patients (53 in an early tracheostomy (ET) group <5 days and 53 in a late tracheostomy (LT) group >5 days) (26). ET patients also had significantly less VAP (34% vs. 64.2%, p=0.0019). Patients in the ET group had significantly shorter ICU stays (21.4 vs. 28.6 days, p<0.0001) and significantly fewer ventilator days (16.7 vs. 21.9 days, p<0.0001) compared to the LT group. This trial estimated a savings of \$2.8 million/year when early tracheostomy is performed (Class III).

In 2009, the EAST Practice Management Guidelines Work Group published findings with regard to tracheostomy (27). Among many other endpoints, the group identified a randomized trial by Rumbak et al. in 2004 that saw a reduction from 25% VAP to 5% VAP when comparing late versus early tracheostomy (28). However, the focus group could not make a recommendation higher than level III when recommending early tracheostomy for the prevention of pneumonia despite evidence that it may decrease the incidence of VAP.

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**Clinical Pulmonary Infection Score (CPIS)**

Parameter	Score
<b><u>Temperature (°C)</u></b>	
≥36.5 and ≤ 38.4	0
≥38.5 and ≤ 38.9	1
≥39.0 or ≤ 36.5	2
<b><u>White Blood Cell (WBC) Count</u></b>	
≥4,000 and ≤ 11,000	0
<4,000 or >11,000	1
<4,000 or > 11,000 & band forms ≥ 50%	2
<b><u>Tracheal Secretions</u></b>	
None or scant	0
Non-purulent	1
Purulent	2
<b><u>PaO<sub>2</sub>/FiO<sub>2</sub></u></b>	
>240, ARDS* or pulmonary contusion	0
≤240 and no ARDS*	2
<b><u>Chest Radiograph</u></b>	
No infiltrate	0
Diffuse (or patchy) infiltrate	1
Localized infiltrate	2

Total CPIS	Action
≤6 and low suspicion for VAP	Evaluate for other potential sources of infection
≤6 and high suspicion for VAP	BAL or mini-BAL
>6	BAL or mini-BAL

\* ARDS is defined as a PaO<sub>2</sub>/FiO<sub>2</sub> ≤200, PAOP ≤18 mmHg, and acute bilateral infiltrates

**Figure 1: Ventilator Associated Pneumonia (VAP) Evaluation Algorithm**

