Essential Practices

A clinical decision-making resource for the respiratory care professional

CDC Recommendations on Preventing VAP

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Mechanical ventilation is required in up to 50% of all critically ill patients during their hospital course. Ventilator-associated pneumonia (VAP) is not uncommon and is known to be associated with increased morbidity, mortality and length of stay. Currently, there is a renewed focus on VAP due to the financial reimbursement with a pay for performance fee structure. The pathogenesis of VAP is hypothesized to be due to the introduction of bacteria into the sterile lower respiratory tract. This article addresses the CDC recommendations for the known modifiable risk factors for VAP, back rest elevation, maintaining endotracheal tube cuff pressure, selection of endotracheal tube and placement, ventilator circuit care, de-contamination of oral flora, and minimizing sedation in the mechanically ventilated patient.

Panel Discussion: Preventing Ventilator-Associated Pneumonia (VAP)

Moderator: Marin Kollef, MD

Panelists: Teresa Volsko, MHHS, RRT, FAARC
Robert Joyner, PhD, RRT
Mark Konkle, MPA, RRT

In this panel discussion, 4 experts convene to discuss topics related to ventilator-associated pneumonia (VAP). Topics include (1) the importance of preventing disruptions in the ventilator circuit in order to prevent ventilator-associated infections such as VAP, iatrogenic viral infections including influenza, and aspiration events; (2) the need for VAP prevention protocols in all ICU's caring for mechanically ventilated patients; (3) the role of cost-effectiveness of novel technologies, including specialized endotracheal tubes for ICU prevention programs; (4) means to minimize exposure to mechanical ventilation as a preventive measure against complications such as VAP; (5) whether VAP should be regarded as a quality indicator of ICU care, and (6) how to employ The Centers for Disease Control and Prevention new criteria for evaluating the quality of care provided in the intensive care setting, ventilator-associated conditions (VACs) and infection-related ventilator-associated conditions (IVACs).

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Mechanical ventilation is required in up to 50% of all critically ill patients during their hospital course. Ventilator-associated pneumonia (VAP) is not uncommon and is known to be associated with increased morbidity, mortality and length of stay. Currently, there is a renewed focus on VAP due to the financial reimbursement with a pay-for-performance fee structure. This becomes problematic since the existing definition of VAP lacks both objectivity and reproducibility. This has led to the development of a new definition encompassing a broader and extended spectrum entitled ventilator-associated complications (VAC).

The pathogenesis of VAP is hypothesized to be due to the introduction of bacteria into the sterile lower respiratory tract. This article addresses the CDC recommendations for the known modifiable risk factors for VAP, back rest elevation, maintaining endotracheal tube cuff pressure, selection of endotracheal tube and placement, ventilator circuit care, decontamination of oral flora, and minimizing sedation in the mechanically ventilated patient. Newer options may be available but evidence is lacking at this time, also recognizing that the current guidelines were established in 2003[1], 2005 (ATS/IDSA)[2] and 2008 (SHEA/IDSA)[3] and an update is pending.

Ventilator-associated pneumonia: defining the problem

Healthcare-associated infections (HAIs) are the most common complication in hospitalized patients. Patients in the ICU frequently need artificial ventilation. Ventilator-associated pneumonia (VAP) is one of the more common infections occurring in these mechanically ventilated patients resulting in antibiotic administration. This leads to prolonged durations of mechanical ventilation, increased intensive care unit (ICU) length-of-stay, and increased hospital costs. VAP is second amongst HAI at $40,144 (95% CI (consumer Index), $36,286-$44,220) for attributable cost.[4] The increased cost, morbidity and mortality make VAP a major healthcare problem needing to be addressed by all ICU providers.[5]

> The increasing occurrence of multidrug-resistant (MDR) or extremely drug-resistant (XDR) pathogens in the ICU is an increasingly important issue.

The Deficit Reduction Act (DRA) of 2005 has directed Medicare to withhold hospital payments for hospital-acquired complications (HAC). Health-care associated infections that lead to a secondary diagnosis will not be reimbursed. HAI are considered to be potentially preventable through the application of evidence-based guidelines. The Centers for Medicare and Medicaid services recently listed VAP as one of the "reasonably preventable diseases."[6] This disease will then be a financial burden to hospitals in the near future.

The major hurdle is accurately defining VAP. The current National Healthcare Safety Network (NHSN) definition used to monitor VAP rates lacks objectivity and reproducibility. This has led to the development of a new definition to help standardize and uniformly report ventilator-associated events (VAE). This new definition uses objective data that can be easily extracted by non-medical personnel and simplifies the process. It uses common physiologic parameters of increasing oxygen or PEEP requirements to screen for ventilator-associated conditions (VAC). This captures both infectious and noninfectious ventilation-associated complications. This definition is in the process of being validated and is planned to be adopted by the NHSN for monitoring of potentially preventable events that includes infections.

The increasing occurrence of multidrug-resistant (MDR) or extremely drug-resistant (XDR) pathogens in the ICU is an increasingly important issue.[7] VAP, as a frequent nosocomial infection, is commonly associated with MDR and XDR bacteria. This then becomes a challenge in selecting empiric antibiotics.[8] Evidence has shown that a delay in appropriate antibiotic administration is associated with increased mortality,[9] but the routine use of empiric broad spectrum antibiotics for only a presumed infection perpetuates the cycle of increasing antibiotic use and the development of resistance.[10] The absence of new classes of antibiotics results in the repeated use of the same classes of antibiotics which also drives the emergence of MDR/XDR pathogens. *Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa,* and Enterobacter species (ESKAPE) pathogens constitute more than 80% of VAP episodes.[11]

Mechanisms for the development of VAP:

Multiple theories for development of VAP have been proposed:

- Oral flora with secretions collecting above the inflated endotracheal tube cuff. These secretions then leak around the cuff and down, and colonize the lower respiratory tract. Pneumonia develops in the susceptible host.
- Aspiration of gastric contents adds to the pool of secretions above the cuff in the heavily sedated and supine patient.
- Development of a biofilm on the surfaces of the ETT allows oral bacteria to propagate into the lower respiratory tract.
- Any break in the closed ventilator system circuitry with inadvertent introduction of bacteria into it.

All currently recommended modali-

ties for the prevention of VAP target these proposed mechanisms.

Preventative strategies directed at VAP

Avoiding or early discontinuation of invasive mechanical ventilation

The most effective way to prevent VAP is to avoid intubation in the appropriate clinical settings. Noninvasive positive-pressure ventilation with the use of a face mask, in conditions such as acute exacerbations of chronic obstructive pulmonary disease,[12] acute hypoxemic respiratory failure secondary to congestive heart failure, and in immunosuppressed patients with pulmonary infiltrates are all associated with improved outcomes and reduced VAP events.[13]

Once intubated, strategies such as sedation vacations, and the use of nursing and respiratory therapist-driven weaning protocols have reduced the time spent on the mechanical ventilator.[14,15] Reducing the number of days on mechanical ventilation is associated with a reduced rate of VAP.[16] This strategy of reduced sedation is not without risks and may lead to self-extubation. Reintubation itself increases the risk of VAP,[17] presumably due to aspiration.

Selection and type of airway

The use of oral endotracheal and orogastric tubes is recommended with a reported reduced rate of sinusitis and possible VAP.[18] Nasotracheal and nasogastric tubes have both been linked to nosocomial sinusitis and an associated increase with VAP rates. Nasotracheal tubes have also been associated with the need for increased sedation which may indirectly prolong time on ventilator.

Secretions in the upper airways pool above the ETT cuff in intubated patients. This allows for the leakage of colonized secretions into the lower airways. Several studies have compared the effect of using an ETT with a separate dorsal lumen which allows for continuous aspiration of the subglottic secretions with that of a conventional ETT. These studies show a beneficial association of continuous suctioning of subglottic secretions on the incidence of VAP.[19,20] Yet, none demonstrated a corresponding association with a reduced mortality, ICU length-of-stay, or duration of mechanical ventilation. The aspiration port of these ET tubes clog easily and the continuous suction has the potential to directly injure the oropharynx and proximal airway. The CDC does recommend the use of subglottic secretion drainage endotracheal tubes only if placed at the time of initial intubation. However, the increased cost of these tubes has prevented them from being commonly used. Cuffed endotracheal tubes used with in-line closed circuit suctioning devises should be used, and the ETT cuff should be maintained at 20 mmHg to minimize aspiration of secretions.[21,22]

> The use of passive humidifiers or heat-moisture exchangers (HME) decrease ventilator circuit colonization but have not significantly reduced the incidence of VAP.[1]

Elevating the head of bed

Elevating the head of the bed (HOB) to 45° is another CDC recommendation for VAP prevention. This strategy is based on the observation that gastric reflux and aspiration of gastric contents into the lung may be prevented by placing the patient in a semi-recumbent position with the HOB elevated to 30° to 45°.[23] Experimental trials have demonstrated that backrest elevation is associated with a reduced risk of pulmonary aspiration.[24] Patients maintained with a HOB elevation during the first 24 hours of mechanical ventilation have a 67% decrease in VAP rate according to a multivariable analysis of risk factors associated with VAP. This positive impact has been confirmed in a randomized trial with the highest risk found in those patients receiving enteral nutrition in the supine position.[23] Additional reduction in aspiration risk is provided by avoiding gastric overdistention and by maintaining the endotracheal tube cuff pressure at 20 mmHg.

Maintenance of the ventilator circuit

VAP may also be related to colonization of the ventilator circuit.[25] Several prospective, randomized trials have shown that the frequency of ventilator circuit changes does not affect the incidence of HAP. Condensate collecting in the ventilator circuit can become contaminated from patient secretions[25, 26] and vigilance is required to prevent inadvertently flushing of this condensate into the patient's lower airway especially when turning the patient in bed. The use of passive humidifiers or heat-moisture exchangers (HME) decrease ventilator circuit colonization but have not significantly reduced the incidence of VAP.[19] It is recommended to minimize opening the ventilator circuit, and to keep the ventilator circuit closed during condensate removal. The ventilator circuit and HME are to be changed only when visibly soiled or malfunctioning.[27]

Oral care

The pathophysiology of VAP involves aspiration of contaminated secretions into the lower respiratory tract, and thus efforts have been made to decontaminate the mouth with chlorhexidine to prevent VAP. Chlorhexidine use in this fashion is associated with the prevention of VAP in the trauma and cardiac surgery patient populations.[28,29] According to a recent meta-analysis, oral health care using either chlorhexidine mouthwash or gel is associated with a 40% reduction in the odds of developing ventilator-associated pneumonia in critically ill adults but no difference in mortality, duration of mechanical ventilation or duration of ICU stay was found.[30]

Minimizing patient sedation

There has been a paradigm shift in the management of the use of sedation and analgesia in mechanically ventilated patients. Heavy sedation suppresses the cough and increases the risk for aspiration with the associated risk for VAP. Additionally, heavy continuous sedation results in prolonged time on the ventila-

tor. The recommendations are to use daily interruption and light sedation, plus the avoidance of paralytic agents.[14] Recent data suggest that by using a non-benzodiazepine-based, analgesia-centered sedation regimen one may decrease time on the ventilator and the associated decrease risk for VAP.[31]

VAP "Bundle"

Multiple groups have instituted VAP bundles that utilize evidence-based guidelines, education, and monitoring of compliance following the implementation of these "bundles".[31] The range has been from the relatively simple Institute for Healthcare Improvement (IHI) 5-point (2010) VAP bundle to the more rigorous 8-point bundle by Bouadma and colleagues.[31] All have demonstrated the importance of compliance with all the components of the bundles to achieve a significant decrease in the incidence of VAP.

Bird and coworkers[28] in a 38-month study in a surgical ICU compared the VAP rates before and after initiation of the IHI bundle. The VAP rate was 10.2 cases per 1000 ventilator days before use of the bundle. During the study period, the rate decreased to 3.4 cases per 1000 ventilator days. The authors concluded that the use of a VAP bundle was an effective method for reducing VAP rates when compliance with the protocols was maintained.

Conclusion

Ventilator-associated pneumonia is not only associated with significant increases in morbidity, mortality and length of stay with the associated increase in attributable health care costs, but current United States healthcare policies will limit financial reimbursement to hospitals with performance-based fee structures. This would mean no reimbursement for preventable processes, such as VAP. With little investment in institutional costs and expenditures, by focusing on education, implementation and monitoring of compliance with "ventilator bundles" based on evidence-based medicine guidelines, hospitals can significantly reduce the incidence of and prevent VAP. This will result in improved patient-focused clinical outcomes and improved payments to hospitals.

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Essential Practices

Panel Discussion

Panel Discussion: Preventing Ventilator-Associated Pneumonia (VAP)

Moderator: Marin Kollef, MD

Panelists: Teresa Volsko, MHHS, RRT, FAARC

Robert Joyner, PhD, RRT

Mark Konkle, MPA, RRT

What is the importance of preventing disruptions in the ventilator circuit (i.e. repeated opening of the ventilator circuit) in order to prevent ventilator-associated infections such as VAP, iatrogenic viral infections including influenza, and aspiration events.

Volsko: Conventional wisdom dictates that fewer disruptions in the ventilator circuit result in a lower risk of contamination. However, care of the ventilator circuit should extend beyond just focusing on repeated opening of the ventilator circuit. Movement of the ventilator circuit during routine bedside care can contribute to inadvertent lavage of contaminated condensation and pathogens into the trachea and lungs. Although there is a dearth of evidence available for VAP prevention in infants, the available literature focuses on the prevention of aspiration and bacterial colonization.

> Conventional wisdom dictates that fewer disruptions in the ventilator circuit result in a lower risk of contamination.
>
> - Volsko -

Bigham and coworkers demonstrated that routinely draining ventilator circuit condensate, especially immediately prior to providing care coupled with the use of subglottic suctioning prior to providing care or repositioning patients were key elements in preventing aspiration events.[1] Minimizing interruptions in the ventilator circuit, including lengthening time intervals between ventilator circuit and inline suction catheter changes may prevent inadvertent aspiration of ventilator condensate and reduce bacterial colonization. The American Association for Respiratory Care (AARC) evidence-based guideline on care of the ventilator circuit recommends that ventilator circuits should not be changed routinely for the purpose of infection control. This is based on evidence suggesting no patient harm and considerable cost savings associated with extended ventilator circuit change intervals.[2] In alignment with the AARC's clinical practice guideline, the American Association of Critical Care Nurses (AACN) recommend ventilator circuits be changed on an as-needed basis, only when the circuits are visibly soiled or malfunctioning, rather than routinely.[3]

There is insufficient evidence with regard to the maximum duration of time that circuits can be safely used in children. However, the literature does report the value of extending ventilator circuit changes in the pediatric population. Samransamruajkit and colleagues reported a reduction in VAP rate from 13.9 cases per 1000 ventilator days to 11.5 cases per 1000 days for circuit changes every 3 and 7 days respectively.[4] A concomitant costs savings in medical supplies and labor costs of $22,000.00 and decrease in PICU length of stay and mortality rate were also associated with the 7-day ventilator circuit change policy.

Joyner: There are well-studied reasons to limit disruptions in the ventilator circuit including limiting fluctuation in systemic arterial pressure, minimization of elevated intracranial pressure, and a reduction in the magnitude of arterial oxygen desaturation.[5] With that said, I don't believe the risk of ventilator-associated pneumonia whether it be through bacterial, viral or other sources is reduced by a reduction in circuit disruptions. I would argue that the most common and frequent reason to disrupt the ventilator circuit would be to suction the endotracheal tube. In 2008, Siempos and colleagues published a meta-analysis of randomized controlled trials comparing closed and open tracheal suction systems.[6] Evaluating 9 trials, they found no benefit on the incidence of ventilator-associated pneumonia, patient mortality, or length of stay in the ICU. While it seems prudent to limit the disruptions of the ventilator circuit for many physiologic and pathologic reasons, doing so as a sole attempt to reduce the incidence of ventilator-associated pneumonia would seem to have minimal effect.

Konkle: The benefits of preventing airway/circuit disconnection and other related disruptions are 2-fold. First, minimizing disruptions helps prevent inadvertent

exposure of contaminants to the airway and lungs. As demonstrated in the literature, the effects of PEEP and positive pressure aids in keeping secretions that pool above the cuff from entering the lungs. In related matters, general circuit upkeep is critical in avoiding conditions that predispose mechanically ventilated patients to an infectious environment. Specifically, practitioner diligence in keeping circuits free of condensates generated by active humidifiers to prevent circuit induced aspiration; performing regular changes of HME's when employed; and other measures important to minimizing the negative effects that comes with the use of mechanical ventilation (MV) equipment.

Second, there is therapeutic benefit as a primary strategy for the prevention of acute lung injury (ALI)/ARDS of maintaining lung unit recruitment, as a result of the application of PEEP and positive pressure within the lungs. While circuit breaks increase the risk of inadvertent direct airway contamination from secretions at rest above the cuff, preventing collapse and promoting/sustaining a "healthy lung state" is an underlying benefit in the prevention of lung infection, in addition to avoiding exposure to contaminants.

Should VAP prevention protocols be required in all ICU's caring for mechanically ventilated patients? If so, what are the requirements for such protocols in terms of interventions, monitoring compliance and effectiveness, and evaluating updates for the protocols?

Volsko: VAP, the second most common hospital-acquired infection in pediatric intensive care units, is associated with increased morbidity, mortality and contributes to prolonged ventilated days, as well as hospital and intensive care lengths of stay, all of which tremendously impact health care costs.[7] VAP occurs in about 5% of intubated, mechanically-ventilated children.[8] Approximately 20% of children who acquire VAP die.[7,9] VAP represents a significant risk factor for complications and death among preterm infants, especially those at or below 28 weeks gestation, (OR: 3.4; 95% CI: 1.20 to 12.31).[10]

The literature supports the implementation of VAP prevention bundles, and demonstrates the potential for decreasing mortality, improving patient outcomes, decreasing ventilator use, intensive care and hospital lengths of stay, and reducing hospital costs.[11,12] Moreover, the Institute for Healthcare Improvement (IHI) also promotes use of the ventilator bundle as a set of interventions intended to prevent adverse events in ventilated patients.[13]

A multidisciplinary improvement team approach for VAP prevention bundle should be embraced. The literature suggests key elements of the pediatric specific VAP prevention bundle be divided into those designed to reduce bacterial colonization and those designed to reduce aspiration of contaminated secretions. Cooper and Haut recommend an evidence based VAP prevention bundle based on studies conducted in the pediatric population. These recommendations included many of the elements proposed in the literature for the adult population and are as follows;[14]

Bundle components aimed at reducing aspiration of contaminated secretions:

1. Elevate the head of the bed 35 to 45 degrees.
2. Drain ventilator circuit condensate every 2-4 hours and before repositioning patient.
3. Use endotracheal tube with dorsal lumen above endotracheal cuff to help suction secretions above the cuff for children more than 12 years old.
4. Change ventilator circuit every 7 days or when circuit is visibly soiled or malfunctioning.
5. Suction endotracheal tube only when indicated by a clinical examination; do not routinely instill physiological saline for suctioning.

Bundle components aimed at reducing bacterial colonization:

1. Perform hand hygiene before and after contact with the patient or any of the ventilator components.
2. Rinse oral suction devices after use and store in non-sealed plastic bag at the bedside when not in use.
3. Provide oral care according to the patient's age:
   a. Neonates and infants with no teeth:
      - Every 2 hours: moisten mouth with swabs soaked in clean water or physiological saline.
   b. Infants and children <6 years old with teeth:
      - Every 12 hours: brush teeth with small, soft toothbrush and fluoride toothpaste; suction out excess toothpaste, but do not rinse out mouth.
   c. Children ≥6 years old with teeth:
      - Every 12 hours: Brush teeth with small, soft toothbrush and fluoride toothpaste; suction out excess toothpaste, but do not rinse out mouth. Rinse mouth with 1% chlorhexidine: irrigate with a syringe or wipe oral mucosa with a swab; suction excess solution, but do not rinse out mouth with water; use at least 30 minutes after brushing teeth.
      - Every 2 hours: Moisten mouth with swabs soaked in clean water or physiological saline

Monitoring compliance and effectiveness of VAP bundles should follow the basic principles of any quality initiative which include: (1) defining the problem, (2) measuring baseline data or current state, (3) identifying key aspects for improvement, (4) implementing the improvement and monitoring and (5) reporting results to gauge gains and sustain the change.[15] Improving quality and patient outcomes is a process, not a single act. Staff engagement is essential in the development, implementation and monitoring of VAP bundles. Engaging bedside champions to be leaders for the VAP initiative contributes to bedside clinician ownership. Staff champions should actively engage in monitoring VAP bundle adherence and reporting real-time data to drive and sustain change. Bigham and colleagues reported 4 process indicators that were effective in reducing VAP rates and sustaining their gains.[1] Specifically, (1) a multidisciplinary leadership team, (2) staff engagement with educating, monitoring and reporting outcomes, (3) the use of bundle checklists, which included an option for clinical staff to provide rapid feedback about positive or negative changes and (4) real time reporting through weekly bundle compliance report posting to provide visual cues of the correlation between increasing bundle compliance and decreasing VAP rates.

Joyner: Various professional organizations including the AARC, ATS, Institute for Clinical Systems Improvement, etc. all advocate prevention as the top issue for VAP.[16] Of these standardized approaches to patient care I think 3 are the most obvious for preventing VAP and should be at the front of every practitioners mind when working with patients at risk of respiratory failure: 1) avoid intubation if possible; 2) utilize non-invasive ventilation where possible; and 3) reduce duration of ventilation as much as possible (including use of sedation holidays, and other strategies that shorten the process of liberation from mechanical ventilation).

When intubation is unavoidable all practitioners should be diligent about assuring the following: maintain the head of bed at 30 to 45 degrees where feasible; orotracheal intubation and orogastric tubes are preferred; place an appropriate sized endotracheal tube and inflate the cuff to a minimal pressure to prevent contaminated oral fluids from leaking into the trachea; eliminate contaminated condensate within the ventilator tubing in a manner that prevents the fluids from entering the endotracheal tube, nebulizer or other intra-circuit devices; passive humidity and heat-moisture-exchangers should be used where possible and change only when visibly contaminated; utilize clinical strategies that prevent aspiration of contaminated oral secretions from entering the trachea (e.g. endotracheal tubes capable of subglottic suctioning); and use enteral feeding when possible.

All of these practice recommendations must be accompanied by a diligent quality assurance program that assesses practitioner compliance and effectiveness of the strategies being employed to prevent VAP. This data should be shared with the practitioners in a manner that allows them to have ownership over the data and promotes the realization that their actions are having an effect on the patients' outcome.

Konkle: Infection prevention practices based on best outcomes are essential for the modern age ICU. Published findings set the foundation for guiding care methods and clinical protocols. There is much evidence on the benefits of airway/respiratory specific interventions ranging from artificial airway tube selection and intubation, to weaning and extubation. Most noteworthy are: 1) whenever possible, controlled intubation proceeded with oral rinse and gargle using chlorhexidine; 2) avoid the nasal-pharyngeal intubation route; 3) at minimum, use endotracheal tubes designs that minimize leakage at the cuff-trachea interface – tapered-cuff over traditional shape design, and polyurethane over polyvinyl chloride in cuff material – or a subglottic secretion drainage (SSD) tube; 4) Q2-4 deep oral suctioning; 5) limit the use of tracheal lavage when suctioning; 6) maintain cuff inflation pressures of >20 cmH_2O; 7) pair sedation relief with daily wean assessments/spontaneous breathing trials; 8) wipe down equipment with disinfectants whenever removing it from the patient's room; and, 9) wash your hands.

> Various professional organizations including the AARC, ATS, Institute for Clinical Systems Improvement, etc. all advocate prevention as the top issue for VAP.
>
> - Joyner -

Other targeted actions shown to contribute in VAP prevention, often referenced within a "vent-bundle" (VB), include head of bed (HOD) elevation at 30 to 45 degrees; GI decontamination; glucose/insulin monitoring and use protocols; and limiting patient transports. These protocol actions, for the most part, are driven by time intervals for completion. It appears that a majority of protocol monitoring takes the form of retrospective reviews of care action compliance by practitioners against the expected responsibilities within these VB protocols. Clinical information systems and the ever-increasing presence of computer-aided monitoring/documentation have presented the opportunity for certain institutions to change to more concurrent screening. When employed, prompts based on VB criteria trigger alerts to identify the need for intervention before reaching critical states, referred to by some as keeping the patient in the green zone.

Should novel technologies, including specialized endotracheal tubes (e.g. subglottic suction, silver coated) be routinely included in ICU prevention programs? Describe how the cost-effectiveness of such technologies should be evaluated at the individual ICU level.

Volsko: The availability of novel technologies, such as specialized endotracheal tubes with suction above the glottis or silver-sulfadiazine-coated endotracheal tubes is limited for very young patients (less than 12 years of age). Therefore, it is difficult to comment on the routine use of these devices in small infants and children requiring invasive ventilatory support.

Adherence rates of 95% to all of the basic components of a VAP bundle (sedation vacation, hand hygiene, preventing inadvertent aspiration of secretions by elevating the head of the bead and performing oral care, preventing stomach ulcers and deep vein thrombosis prophylaxis) substantially improved VAP rates ($p<.01$) among adult ICU patients.[17] Brilli demonstrated the cost-effectiveness of a pediatric VAP bundle through a reduction in hospital length of stay for non-VAP patients by 400 days, unreimbursed cost of care by $442,789, and hospital costs by $2,353,222 for their 13 patient cohort. [18]

Prior to the implementation of novel technologies, it is essential to achieve at least 95% adherence to the VAP bundle and determine baseline cost, VAP rate, morbidity and mortality data. Quality and cost data can then be compared before and after the introduction of a novel technology to the bundle. The cost of the novel device must be factored into the

analysis to determine if the technology has an impact on patient outcome and how the cost associated with using the device impacts the cost of care.

Joyner: Hospital charges for patients diagnosed with VAP have been estimated to be about $35,000 higher per patient than patients who are not diagnosed with VAP. These costs arise from longer lengths of ventilation, longer ICU stays, and increased use of various hospital services.[19] Unsurprisingly, it follows that reducing the incidence of VAP is a common topic of study. Recently, a conference summary was published on this topic in the journal, Respiratory Care.[20] The theoretical approach to determining whether a procedure or device is cost effective is convoluted and sometimes lost to practitioners and administrators. Essentially, the number of patients needed to treat before you observe a desired outcome must be determined. The leap of faith is that not everyone will benefit from an expensive intervention (e.g. silver-coated endotracheal tubes that can cost 50 to 100 times more than a traditional endotracheal tube). In a manner that is almost like medicinal gambling, patients are treated without specifically knowing the individual will benefit, but understanding that some who are treated will benefit. Eventually the gamble will pay off and a patient who would have otherwise been afflicted with VAP would have been prevented from getting it. The benefit can be measured with average rates of occurrence, but rarely can a single patient be pointed to as being one of the beneficiaries of the expensive intervention.

With that said, there is enough data available to suggest we should not use these devices in every patient. There are some patients who clearly would not benefit; for example, uncomplicated surgical patients who are likely to be extubated within a few hours of admitting into the ICU. There may be a few patients who can be identified as at risk for VAP and likely benefit from expensive therapies, for example, the immunocompromised patient who is likely to be intubated for a few days. Additional studies are needed to determine which patients are most likely to benefit from these interventions and, therefore, I do not recommend their routine use. As studies provide more data to allow a better understanding of patient populations that benefit from these interventions, I believe routine use on selected patients is not far into the future.

Hospital charges for patients diagnosed with VAP have been estimated to be about $35,000 higher per patient than patients who are not diagnosed with VAP.

- Joyner -

Konkle: Lacherade and other researchers work support the effectiveness of subglottic secretion drainage (SSD) on "reducing microbiologically confirmed VAP"; however, there was little impact on VAP cases using clinically confirmed VAP criteria.[21] It was noted by Koulenti's group that approximately 40% of VAP occurrences are not microbiologically proven.[22] This does raise the question of whether or not SSD and other innovations should be widespread employed. Might frequent routine oral care/deep oral suctioning be just as beneficial? A brief quality study where respiratory therapists were charged with performing this practice under protocol guidelines demonstrated a positive improvement in VAP reduction in that particular hospital. Given our moderator of this edition, I will bow to my fellow panelists to debate the use of silver-coated ET-Tubes more thoroughly.

The empirical cost of changing a procedure is a clear process to determine. In basic terms, by examining the net change in supply expense and the net change in time between the current state and future state of practice(s) in question, the cost of resources can be derived for the inputs of care. Determining the effectiveness of the cost of undertaking a care change has shortcomings. This effectiveness is dependent on the value of the outcome being sought, in dollars and "care-value." Where lies some of the difficulty is that these outcomes are often expected rather than guaranteed and are not independent of complimentary or other variables such as compliance with protocols, adjunctive procedures being performed by other caregivers, pharmaceutical advances, the ease/reliability of measuring the outcome, and the overall dynamics of the care environment. Frequently, there is a lapse in time when input costs occur and results become stable enough to be reliable or even measurable. These periods of stability can range from weeks to years in certain cases or are simply not achievable in the desired timeframes. When the variation among institutions differs in leadership philosophies, then comfort with risk, budget time frames and cost recovery strategies and determining effectiveness is complicated further.

Minimizing exposure to mechanical ventilation is universally regarded as a beneficial outcome to prevention of complications such as VAP. Which of the following approaches to achieving this goal should be routinely employed: sedation minimization protocols, early-tracheostomy, use of weaning protocols, use of noninvasive ventilation and checklists to foster early extubation?

Volsko: The use of noninvasive ventilation (NIV) has been embraced in the pediatric population as a mechanism to reduce the morbidity associated with ventilatory support. For preterm infants this can be seen through an insurgence of bronchopulmonary dysplasia (BPD) and sepsis.[23] In addition to minimizing the risk of VAP, the use of bubble continuous positive airway pressure (CPAP), and strategies that promote early extubation followed by the use of noninvasive respiratory support were effective in preventing complications such bronchopulmonary dysplasia (BPD)[24-26] low grade intraventricular hemorrhage,[24] and hypotension.[25]

The literature demonstrates that the use of NIV in children with bronchiolitis can reduce the need for intubation and subsequent risk for VAP. When the use of NIV does not result in the need to intubate, there is a decreased rate of ventilator-associated pneumonia, reduced duration of oxygen requirement and is not pro-

longed.[27] However, it is important to note that when employed initially to avoid endotracheal intubation, failure of NIV was associated with increased duration of invasive ventilation and pediatric ICU LOS.[28,29]

Although the protocols for each of the aforementioned studies varied, there was a common denominator. Each study incorporated well defined intubation and extubation criteria and a mechanism for protocol adherence surveillance and reporting. This is a common theme seen throughout the pediatric literature and one that is key to achieving and sustaining positive patient outcomes.

Joyner: As Teresa indicated, where possible, every effort should be taken to minimize invasive mechanical ventilation. I believe there is value in creating ventilator liberation teams that assess and advocate for liberation of patients from ventilators. The teams would benefit busy ICUs where it is difficult for the staff to remain focused on some details of patients, like the need to assess for appropriateness of extubation. The treatment of patients who are in the process of being liberated from their ventilator is time consuming. It is much easier to care for a patient that is profoundly sedated. Care teams that could evaluate and advocate for sedation holidays, weaning protocols, and noninvasive ventilation, may provide for a reduction in VAP.

Konkle: All of these mentioned approaches have benefit in MV avoidance. Of particular interest to me, are non-invasive ventilation (NIV) and protocols for weaning/liberation from MV. Most would agree that evidence shows that NIV improves outcome in certain patient populations, yet it is underutilized. Successful NIV use begins with a foundation in the clinical decision pathway at an institutional level, not just departmental. Along with establishing a wide-based protocol, it is essential for NIV to become an everyday behavior of bedside practitioners where it can be applied prior to intubation/MV or as a bridge for early extubation. Davies, Hess, Kallet, Keenan and others provide thorough frameworks and highlight the major elements necessary for implementing a successful NIV program. These include basics such as availability of the required equipment with an array of interface (mask) options; arrangements to allocate ample therapist time during administration; provision of an appropriate monitoring environment; and establishment of clinical guidelines for actual application to targeted patient populations.

Along with establishing a wide-based protocol, it is essential for NIV to become an everyday behavior of bedside practitioners where it can be applied prior to intubation/ MV or as a bridge for early extubation.

- Konkle -

A more difficult and possibly the critical factor for NIV program success is in developing the initiative with cooperation and full support of the medical/nursing staff, then gaining experience. This can be a challenging task in some care environments such as those with academic responsibilities or those where physician, nursing and therapist workforce turnover is elevated. In high turnover states, establishing firm care practices and growing the everyday bedside experience does not easily become seated in caregiver behaviors.

Once intubation and commitment to MV are inevitable, a focus toward liberation from MV is paramount. At minimum, daily wean assessments and spontaneous breathing trials (SBT) are essential. Focus should be placed on addressing the barriers of the causes of failed trials. These could range from poor timing with sedation relief and improved communication between caregivers, to more effective treatment of the patient's underlying condition.

Should VAP be regarded as a quality indicator of ICU care? If not, what other quality indicators should be used to determine the overall quality of ICU care from a benchmarking standpoint?

Volsko: The costs associated with VAP in terms of morbidity, mortality and overall cost of care are well established. I firmly believe that VAP rates should be regarded as a quality indicator of ICU care. However, with the use of strategies such as NIV and high flow oxygen therapy aimed at averting intubation, counter balancing measures such as ICU length of stay, failed NIV rate, and total ventilator LOS and total cost of care should also be tracked. Tracking balancing measures provides a more complete view of the overall quality of respiratory care provided to patients in need of ventilatory assistance.

Joyner: I think VAP cannot be used as an indicator. Patient populations vary so much between geographical areas that a single indicator does not provide a marker of quality care. By comparing peer institutions and then indexing VAP by the demographics of the diseases treated and severity of diseases treated in a particular ICU, an indicator of quality may be able to be developed. As an example, I do not believe it would be fair to compare a community-based hospital ICU with a more suburban teaching hospital.

Konkle: VAP should continue to be included as one of the metrics for which to measure ICU quality of care; at least for the short-term (<5 years), until the new CDC VAE surveillance reporting matures. Though the exiting VAP surveillance method is plagued with shortcomings and is vulnerable to certain degrees of "impurity or manipulation," the measure of VAP-free days remains one of the few global or institutional parameters that has longevity in reporting. Michael Klompas MD, Meduri, and others present sound rationale on the difficulty of the measure VAP-free days and achieving zero VAP. This covers everything from inherent subjectivity in chest radiograph interpretation (criteria put in place in 2002), to signs and symptoms that reflect other conditions which present cautions in VAP rate use as a key marker of ICU quality.

In recent years, the advent of other indicators may provide greater benefit specific to the respiratory care department and its practicing therapists. Of these, I think attention should be paid to obvious markers such as duration of ventilation, length of ICU stay, reintubation rates, and tracheostomy incidence. However, more significant are events pointing to how effective we are we at providing MV and airway support, along with associated interventions. Included here would be measures of: 1) duration at low tidal volume use by gender; 2) SBT frequency; 3) optimum extubation time frames; 4) the tracking of NIV opportunities; and 5) MV actual duration compared to predicted durations.

The Centers for Disease Control and Prevention has developed a new set of criteria for evaluating the quality of care provided in the intensive care setting, ventilator-associated conditions (VACs) and infection-related ventilator-associated conditions (IVACs). How do you envision these new criteria being employed to assess ICU quality and how should hospitals prepare for their eventual implementation?

Volsko: Healthcare organizations employ a variety of measures to reduce the rates of hospital-acquired infection. VAP is often difficult to diagnose and affected by the subjectivity of many components of the surveillance definition. The criteria used to determine VAC appears to be much simpler, and a more objective-based measure of respiratory deterioration. However, with these new criteria comes the daunting task of collecting additional data. It seems imperative that widespread implementation of criteria to capture VAC, IVAC, and VAP events would necessitate integration of data capture with the electronic medical record. There needs to be a mechanism for bedside clinicians to easily track the criteria and pull the patient report with respect to the occurrence of these events through the electronic medical record. The ability to identify factors and promptly address them as a component of the patient's overall plan of care is of value. I envision the expansion of these practices outside of the ICU to all nursing areas of the healthcare organization that care for mechanically ventilated patients (i.e. rehabilitation units and transitional care units that care for tracheostomized, mechanically ventilated patients prior to transition from hospital to the homecare or long-term care environment.

The criteria used to determine VAC appears to be much simpler, and a more objective-based measure of respiratory deterioration.

- Volsko -

Joyner: I think this is a clear attempt to get a handle on a disease process that is perceived to be iatrogenic, but also not defined very well in the literature. Since the 1999 publication of the Institute of Medicine's report, To Err is Human, and as the Affordable Care Act (ACA) moves forward, there is pressure being placed on hospitals to be more accountable for the quality of care that is being provided. Linking reimbursement to the quality of care being provided requires definitions and guidelines to be developed, such as the VACs, IVACs, and VAE Surveillance Protocol published by the CDC. I believe all hospitals will incorporate suggestions provided by governmental agencies such as the CDC for all sorts of care as they are linked to federal reimbursement. In addition to assuring reimbursement, I hope these changes will lead to real improvements in patient outcomes.

Konkle: Changing to VAE/VAC surveillance presents many unknowns, but for the first time an attempt at qualifying the mechanics of ventilatory support is being taken. These include considerations on the dosing pattern of oxygen. A first impression does produce concerns about how this new attention to VAEs might influence bedside practitioners. Will it change therapy behavior toward conservation and decisive actions to reduce event and condition counts? Will this necessarily be in the patient's best interest? If avoidance actions are taken, will it result in lengthening ventilator durations and ICU stays? We don't know.

Since our implementation and review of our institution's report of the initial months of collection, it appears that in its native form it is hard to identify value and is not very useful yet. The value might likely come from looking more closely at the dimensions of the care process that are making up the VAC counts. Specifically, these dimensions of the VACs call attention to what the underlying circumstances and patient conditions are as the root causes. It is anticipated that the counts and distribution of these root dimensions will become more apparent and reveal discrete groups for which to target actions for improvement.

I am not certain one can prepare for their implementation. At the institutional level, it means that the stakeholders involved, such as Respiratory Care, Infection Control, ICU leadership and other key groups are fully informed of what makes up these measures. Then it requires continuing to work among these groups to assure understanding of these data and reports as they become distributed.

For the Respiratory Care Department, continuing to follow and implement best practices that are evidence based remains important regardless of surveillance changes. It is also sound advice to actively participate in the rollout of the program and collaborate with the primary stakeholders in: 1) reviewing trends, 2) understanding report value, and 3) participating in and taking actions that bring about protocol changes to improve care.

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Questions

1. **The development of VAP is associated with an increase in length of ICU stay.**
   A. True
   B. False

2. **Airway and secretion management are essential in an effort to reducing the occurrence of VAP. Which of these statements does not support this goal.**
   A. By keeping the head of the bed elevated at 30-45 degrees can have a positive effect on preventing aspiration of gastric contents.
   B. Subglottic secretion aspiration is beneficial as it removes contaminants resting above the ETT cuff.
   C. Regular ETT cuff maintenance keeping inflation pressures at 20 mmHg.
   D. The route of endotracheal tube (ETT) and gastric tube placement has no influence on the possibility of VAP.

3. **Which of the following statements regarding head of the bed elevation is correct?**
   A. The patient group who derived the greatest reduction in VAP were those receiving enteral nutrition with the head of the bed elevation.
   B. The CDC recommends elevating the head of the bed to greater than 60 degrees from the horizontal axis.
   C. Checking gastric residuals has no impact in preventing VAP.
   D. None of the above

4. **The utilization of a "VAP bundle" has been shown to decrease the incidence of VAP when institutions have shown compliance with its use.**
   A. True
   B. False

5. **Which of the following statements regarding sedation use associated with invasive mechanical ventilation is correct:**
   A. Heavy sedation increases the risk for inadvertent extubation.
   B. Use of continuous sedation has been associated with prolonged duration of ventilation.
   C . Daily interruption in sedation (sedation vacation) does not change the overall amount of sedation used
   d. None of the above

6. **The condensate (rain out) within the ventilator circuit should be removed immediately.**
   A. True
   B. False

7. **Considering oral care which of the following statements is not true.**
   A. There is little evidence suggesting that special oral care measures are any better that daily brushing/ swabbing of an intubated patient's teeth and gums.
   B. Routine oral care is considered part of the VAP bundle targeted at reducing rates of ventilator-associated pneumonia.
   C. One pharmaceutical agent, chlorhexidine, either in mouth rinse or gel form has shown to have impact on decreasing VAP development; however, there was little change in mortality or duration of MV.
   D. Examining the occurrence of VAP and the underlying pathophysiology, aspiration of contaminated secretions plays an important role.

8. **Choose the statement below that is not consistent with VAP or VAP bundles.**
   A. To capture the greatest benefit in using a VAP bundle, compliance in all the components is essential.
   B. VAP bundles need to be driven by medical guidelines that are evidence-based.
   C. The incidence of VAP as a preventable affliction will have little, if any, bearing on the reimbursement to hospitals for those cases.
   D. Use of sedation in mechanically ventilated patients has changed to greater conservation and daily interruptions to promote liberation from MV

9. **As a result of shortcomings in measuring VAP rates, the CDC has issued revised guidelines and recommendations using physiologic parameters which has led to defining ventilator-associated events to improve standardization and objectivity in surveillance and reporting.**
   A. True
   B. False

10. **What mechanism has little or no influence in the development of VAP?**
    A. Frequent breaks in the ventilator-patient circuit.
    B. Leakage of the collection of secretions laced with oral flora contaminants above an inflated endotracheal tube cuff.
    C. The blanket use of broad, non-specific antibiotic therapy early after intubation.
    D. The risk of gastric content aspiration in the supine or sedated patient.

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Objectives

Upon completion of the course, the reader was able to:

1. Discuss the pathogenesis of VAP (Ventilator-associated Pneumonia).
   Strongly Agree 1 2 3 4 5 6 Strongly Disagree
2. Describe the economic impact of diagnosing VAP in a patient.
   Strongly Agree 1 2 3 4 5 6 Strongly Disagree
3. Identify the CDC recommended methods of VAP prevention.
   Strongly Agree 1 2 3 4 5 6 Strongly Disagree
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   Strongly Agree 1 2 3 4 5 6 Strongly Disagree

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2	☐	☐	☐	☐	7	☐	☐	☐	☐
3	☐	☐	☐	☐	8	☐	☐	☐	☐
4	☐	☐			9	☐	☐		
5	☐	☐	☐	☐	10	☐	☐	☐	☐

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