Preventing Ventilator-Associated Pneumonia:
Five Components of Care

1. Elevation of the Head of the Bed

Elevation of the head of the bed is an integral part of the Ventilator Bundle and has been correlated with reduction in the rate of ventilator-associated pneumonia. The recommended elevation is between 30 and 45 degrees.

Drakulovic et al. conducted a randomized controlled trial in 86 mechanically ventilated patients assigned to semi-recumbent or supine body position. The trial demonstrated that suspected cases of ventilator-associated pneumonia had an incidence of 34%, while in the semi-recumbent position suspected cases had an incidence of 8% (p=0.003). Similarly, confirmed cases were 23% and 5% respectively (p=0.018). While it is not immediately clear whether the intervention aids in the prevention of ventilator-associated pneumonia by decreasing the risk of aspiration of gastrointestinal contents or oropharyngeal and nasopharyngeal secretions, this was the ostensible reason for the initial recommendation.

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Another reason that the intervention was suggested was to improve patients’ ventilation. For example, patients in the supine position will have lower spontaneous tidal volumes on pressure support ventilation than those seated in an upright position. Although patients may be on mandatory modes of ventilation, the improvement in position may aid ventilatory efforts and minimize atelectasis.

Some concerns with regard to this position have included patients sliding down in bed and, if skin integrity is compromised, shearing of skin. Others have commented on the possibility of patient discomfort. Although it is difficult to assess for these concerns in a controlled manner, anecdotal experience is that neither has been a complaint of care from providers or from patients, once they are off the ventilator and able to speak.

Another randomized controlled trial was completed in the Netherlands that challenged the feasibility of keeping the head of the bed elevated in mechanically ventilated patients. While the purported benefits were not directly challenged, there was great evidence to suggest that keeping the head of the bed at 45 degrees is a more challenging task than would be otherwise imagined. This work underscores the difficulty of keeping the head of the bed elevated and the low reliability with which care teams have been able to maintain this standard under routine conditions.

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What changes can we make that will result in improvement?
Hospital teams across the United States have developed and tested process and system changes that allowed them to improve performance on elevation of the head of the bed. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Implement a mechanism to ensure head-of-the-bed elevation, such as including this intervention on nursing flow sheets and as a topic at multidisciplinary rounds.
- Create an environment where respiratory therapists work collaboratively with nursing to maintain head-of-the-bed elevation.
- Involve families in the process by educating them about the importance of head-of-the-bed elevation and encourage them to notify clinical personnel when the bed does not appear to be in the proper position.
- Use visual cues so it is easy to identify when the bed is in the proper position, such as a line on the wall that can only be seen if the bed is below a 30-degree angle.
- Include this intervention on order sets for initiation and weaning of mechanical ventilation, delivery of tube feedings, and provision of oral care.
- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.
2. Daily Sedative Interruption and Daily Assessment of Readiness to Extubate

Using daily sedative interruptions and assessing the patient’s readiness to extubate are an integral part of the Ventilator Bundle and have been correlated with reduction in the rate of ventilator-associated pneumonia.

Kress et al. conducted a randomized controlled trial in 128 adult mechanically ventilated patients receiving continuous infusion of sedative agents in a medical intensive care unit. Patients were randomized to receive daily interruption of sedation until awake versus management at the clinician’s discretion. Daily interruption resulted in a highly significant reduction in time spent on mechanical ventilation. The duration of mechanical ventilation decreased from 7.3 days to 4.9 days (p=0.004).

In the trial, an investigator interrupted the sedation each day until the patients were awake and could follow instructions or until they became uncomfortable or agitated and were deemed to require the resumption of sedation. A nurse evaluated the patients each day throughout the period when infusions were stopped until the patients were either awake or uncomfortable and in need of resumed sedation. This nurse immediately contacted a study physician when a patient awakened, at which time the study physician examined the patient and decided whether to resume the infusions. The sedative infusions were started again after the patient was awake or, if agitation prevented successful waking, at half the previous rates and were adjusted according to the need for sedation. For complete details as well as handling special circumstances such as use of paralytic agents, please refer to the actual trial.14

Based on this study, it appears that lightening sedation decreases the amount of time spent on mechanical ventilation and therefore the risk of ventilator-associated pneumonia. In addition, weaning patients from ventilators becomes easier when patients are able to assist themselves at extubation with coughing and control of secretions.

Sedative interruptions are not without certain risks, however. For instance, there is a fear that patients who are not deeply sedated may have an increased potential for self-extubation. With experience however, this has not been shown to be the case; in fact, intubated patients randomized to be treated with no sedation did not have an increased rate of unplanned extubations.15 In addition, some have suggested that there may be an increased potential for pain and anxiety associated with lightening sedation. Lastly, increased tone and poor synchrony with the ventilator during the maneuver may risk episodes of desaturation.

Despite these concerns, a comparison of patients receiving sedation interruption versus those patients whose sedation was managed at a clinician’s discretion demonstrates that patients receiving sedation interruption exhibit fewer overall complications. The Kress study data were reviewed in a post-hoc


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analysis and seven distinct complications associated with mechanical ventilation and critical illness were identified: 1) ventilator-associated pneumonia; 2) upper gastrointestinal hemorrhage; 3) bacteremia; 4) barotrauma; 5) venous thromboembolic disease; and 6) cholestasis or 7) sinusitis requiring surgical intervention. Patients undergoing daily interruption of sedative infusions experienced 13 complications (2.8%) vs. 26 complications (6.2%) in those patients subjected to conventional sedation techniques (p = .04). The authors concluded that daily interruption of sedative infusions reduced intensive care unit length of stay and, in turn, decreased the incidence of complications of critical illness associated with prolonged intubation and mechanical ventilation.16

Patients who receive sedation interruption do not appear to be at risk for worse psychological outcomes after critical illness compared with conventional therapies.17

There is some evidence that daily weaning assessments reduce the duration of mechanical ventilation.18,19

What changes can we make that will result in improvement?

Hospitals’ improvement teams from across the United States have developed and tested process and system changes that have allowed them to improve performance on daily sedative interruptions and daily assessment of readiness to extubate. Daily sedation interruption and daily assessment of readiness to extubate are separate, though at times interdependent, processes. Separating the elements can focus a team's work on developing protocols, order sets, standard work for sedation interruption, and weaning assessment. For measurement of compliance with the Ventilator Bundle, though, we count these as one. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Implement a protocol to lighten sedation daily at an appropriate time to assess for neurological readiness to extubate. Include precautions to prevent self-extubation such as increased monitoring and vigilance during the trial.
- Include a sedative interruption strategy in your overall plan to wean the patient from the ventilator; if you have a weaning protocol, add sedative interruption to that strategy.
- Assess compliance each day on multidisciplinary rounds.

• Consider implementation of a sedation scale such as the Richmond Agitation Sedation Scale (RASS)\textsuperscript{20} scale to avoid oversedation.

• Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.

3. Peptic Ulcer Disease (PUD) Prophylaxis

Stress ulcerations are the most common cause of gastrointestinal bleeding in intensive care unit patients, and the presence of gastrointestinal bleeding due to these lesions is associated with a five-fold increase in mortality compared to ICU patients without bleeding. Applying peptic ulcer disease prophylaxis is therefore a necessary intervention in critically ill patients. A concern about prophylactic therapy for stress ulceration has been the potential for increased risk of nosocomial pneumonia. Agents that raise gastric pH may promote the growth of bacteria in the stomach, particularly gram-negative bacilli that originate in the duodenum.

The extent to which reflux of gastric contents and secretions occurs even in healthy individuals suggests that critically-ill ventilated patients are susceptible to aspiration events. Worse, critically-ill intubated patients lack the ability to defend their airway. Esophageal reflux and aspiration of gastric contents along the endotracheal tube may lead to endobronchial colonization and pneumonia or may precipitate pneumonia due to the decreased bacterial killing in the low-acid environment. Elevating the head of the bed should reduce the amount of aspiration patients have.

Nevertheless, a meta-analysis of studies published prior to 1990 did not find an increased incidence of hospital-acquired pneumonia with elevation of gastric pH, although there was a trend towards a reduced rate of pneumonia with the prophylactic use of sucralfate as compared with pH-altering drugs. The American Thoracic Society/Infectious Disease Society of America guidelines concluded that because there is a trend for reduced VAP with sucralfate, but a slightly higher rate of gastric bleeding compared with the use of H2 antagonists, the use of either an H2 antagonist or sucralfate is acceptable.

PUD prophylaxis in the Ventilator Bundle is that provided with medications; H2 blockers are preferred over sucralfate. Proton pump inhibitors (PPIs) may be efficacious, and an alternative to sucralfate or H2 antagonist. They have become the standard of care in many ICUs now that the formulations are available in intravenous form (prior to the introduction of IV pantoprazole in 2001, they were only available orally). The evidence is that PPIs are at least as good as H2 blockers, and possibly better. Proton pump inhibitors tend to provide more consistent pH control than histamine H(2) receptor antagonists. There is a paucity of data comparing these regimens, but the evidence that does exist indicates it is as good as H2 blockers.

Questions arise as to whether PUD prophylaxis is appropriate due to risk of *C. difficile*. Use of any gastric acid suppressive agent could be a risk factor for *C. difficile*, and ICU patients might be receiving several things that increase the risk of *C. difficile*. PPIs and H2 blockers have been associated with C. diff in community-acquired disease, and although there do not appear to be reports in the literature about ICU-acquired C. diff associated with this, it stands to reason that there may be an association in hospital-acquired C. diff. For ventilated patients in the ICU setting, stress ulcer prophylaxis may be more beneficial than the potential for this risk. As with any clinical intervention, the risk/benefit analysis must occur to ensure that the patient receives care that has greater potential benefit than risk.²⁷

It is important to note that this is not a requirement to provide prophylaxis in cases where the physician believes the risks outweigh the benefits. In such cases, as long as there is dialogue among the clinical team regarding the appropriateness of the intervention and the reasons for an alternate decision are documented, the intent of the Ventilator Bundle has been met.

**What changes can we make that will result in improvement?**

Hospital teams across the United States have developed and tested process and system changes that allowed them to improve performance on peptic ulcer disease prophylaxis. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Include peptic ulcer disease prophylaxis as part of your ICU order admission set and ventilator order set. Make application of prophylaxis the default value on the form.
- Include peptic ulcer disease prophylaxis as an item for discussion on daily multidisciplinary rounds. Count this item as “met” if the discussion occurs and is documented, even if there is a decision not to provide this intervention.
- Empower pharmacy to review patients in the ICU to ensure that some form of peptic ulcer disease prophylaxis is provided for all appropriate ICU patients.
- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.

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4. Deep Venous Thrombosis (DVT) Prophylaxis

Applying deep venous thrombosis prophylaxis is an appropriate intervention in all patients who are sedentary; however, the higher incidence of deep venous thrombosis in critical illness justifies greater vigilance.

The risk of venous thromboembolism is reduced if prophylaxis is consistently applied. A clinical practice guideline issued as part of the Seventh American College of Chest Physicians Conference on Antithrombotic and Thrombolytic Therapy recommends prophylaxis for patients undergoing surgery, trauma patients, acutely ill medical patients, and patients admitted to the intensive care unit. The level of cited evidence was that of several randomized controlled trials. 28

While it is unclear if there is any association between DVT prophylaxis and decreasing rates of ventilator-associated pneumonia, our experience is that VAP rates decreased most dramatically in hospitals where all elements of the Ventilator Bundle were implemented, including this one. The intervention remains excellent practice in the general care of ventilated patients.

Important considerations include that the risk of bleeding may increase if anticoagulants are used to accomplish prophylaxis. When prophylactic anticoagulation cannot be used because of high risk of bleeding, sequential compression devices may be used. Often, sequential compression devices are not applied reliably to patients when they go to or return from procedures negating their effectiveness.

What changes can we make that will result in improvement?

Hospital teams across the United States have developed and tested process and system changes that allowed them to improve performance on deep venous thrombosis prophylaxis. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Include deep venous thrombosis prophylaxis as part of your ICU order admission set and ventilator order set. Make application of prophylaxis the default value on the form.

- Include deep venous thrombosis prophylaxis as an item for discussion on daily multidisciplinary rounds. Count this item as “met” if the discussion occurs and is documented, even if there is a decision not to provide this intervention.

- Empower pharmacy to review orders for patients in the ICU to ensure that some form of deep venous thrombosis prophylaxis is in place at all times on ICU patients.

- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.

5. Daily Oral Care with Chlorhexidine

IHI added this fifth element of care to the Ventilator Bundle in May 2010 following continued review of the literature and use of the element in the Ventilator Bundle in Scotland for over a year.

Dental plaque biofilms are colonized by respiratory pathogens in mechanically ventilated patients. Dental plaque develops in patients that are mechanically ventilated because of the lack of mechanical chewing and the absence of saliva, which minimizes the development of biofilm on the teeth. Dental plaque can be a significant reservoir for potential respiratory pathogens that cause ventilator-associated pneumonia. Chlorhexidine antiseptic has long been approved as an inhibitor of dental plaque formation and gingivitis. As early as 1996, DeRiso and colleagues published a study which provided evidence to support the use of 0.12% chlorhexidine oral rinse as a prophylactic measure to reduce nosocomial respiratory tract infections in cardiac surgery patients.29

Since that time there has been much discussion about the utilization of chlorhexidine as an important adjunct to oral hygiene, but there have been few studies published that provide firm evidence that the use of chlorhexidine as a decontamination antiseptic reduces the incidence of ventilator-associated pneumonia. Chlorhexidine has been studied in two strengths: 0.12% and 0.2%. The US Food and Drug Administration recommends 0.12% oral chlorhexidine for use as mouth rinse. In a meta-analysis by Chan and colleagues published in 2007 in the British Medical Journal, eleven studies were evaluated for effect of oral decontamination on the incidence of ventilator-associated pneumonia and mortality in mechanically ventilated adults. Results of that analysis concluded that oral decontamination of mechanically ventilated adults using chlorhexidine is associated with a lower risk of ventilator-associated pneumonia.30

There is little, if any, evidence of other oral care processes having an effect on the development of VAP, but it makes sense that good oral hygiene and the use of antiseptic oral decontamination reduces the bacteria on the oral mucosa and the potential for bacterial colonization in the upper respiratory tract. This reduction in bacteria has been shown to reduce the potential for the development in ventilator-associated pneumonia for patients on mechanical ventilation.31

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What changes can we make that will result in improvement?
Hospital teams across the United States have developed and tested process and system changes that allowed them to improve performance on daily oral care with chlorhexidine. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Include daily oral care with chlorhexidine as part of your ICU order admission set and ventilator order set. Make application of prophylaxis the default value on the form.
- Include daily oral care with chlorhexidine as an item for discussion on daily multidisciplinary rounds. Count this item as “met” if the discussion occurs and is documented, even if there is a decision not to provide this intervention.
- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.
- Educate the RN staff about the rationale supporting good oral hygiene and its potential benefit in reducing ventilator-associated pneumonia.
- Develop a comprehensive oral care process that includes the use of 0.12% chlorhexidine oral rinse.
- Schedule chlorhexidine as a medication, which then provides a reminder for the RN and triggers the oral care process delivery.