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Prevention of Aspiration Pneumonia in the Enterally Fed Critically Ill Ventilated Patients: Keeping the Head Up Takes a Village!

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One of the most serious complications in the critically ill patient is aspiration resulting in healthcare associated pneumonia. Bedside methods to detect aspiration such as blue dye in enteral formulas and glucose testing of pulmonary secretions have fallen short of the goal. Recognizing that prevention of an aspiration event is essential to good outcomes, investigators have sought to determine the relationship of other variables such as intubation status, backrest elevation, vomiting, mental status and gastric residual volumes to aspiration and the subsequent development of pneumonia. Of the identified risk factors, back rest elevation (BRE) is one of the most modifiable, however, all health care providers must play a role in accomplishing this task. Studies to date demonstrate how difficult this intervention is to achieve. This paper discusses these topics and suggests how the healthcare team might work together to proactively, and positively, effect outcomes in this vulnerable patient population.

INTRODUCTION

Aspiration pneumonia in the critically ill ventilated patient is a serious complication of enteral nutrition (EN), but can also occur even in the absence of feedings, such as with the aspiration of endogenous secretions or saliva. This is especially true in patients who have decreased mental status, are unable to protect their airway, and/or are intubated and mechanically ventilated (MV) (1–6). Within 24–48 hours of exposure to a healthcare environment, organisms ubiquitous to the environment (*pseudomonas aeruginosa, staphylococcus aureus, methicillin resistant,* and *staphylococcus aureus*), colonize the patients' artificial airway (called a biofilm), and with

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Table 1
Prevention of VAP: top recommendations for practice (by discipline)

Guideline Recommendations for practice implementation (ATS, CDC, AACN, CCCT/CCCS)	*Disciplines responsible*
Hand washing and aseptic technique	All bedside clinicians: RN, RCP, MD, Nutritionists, PT
BRE (> 30–45 degrees)	All bedside clinicians: RN, RCP, MD, Nutritionists, PT
CASS tubes	RCP, MD, RN
No routine ventilator circuit changes	RCP, MD, RN

Key: BRE = backrest elevation, VAP = ventilator associated pneumonia, RCP = Respiratory Care Practitioner, PT = Physical Therapist, CASS = continuous aspiration subglottic suctioning, ATS = American Thoracic Society, AACN = American Association of Critical-Care Nurses, CCCT/CCCS = Canadian Critical Care Trials Group and the Canadian Critical Care Society

micro- or gross aspiration, may result in pneumonia (6,7). Sources of the organisms may be airborne and/or seeded from the mouth, sinuses or stomach (8). While it is true that not all aspirations result in pneumonia, those that do so negatively affect morbidity, mortality, length of stay (LOS) and cost (1,4,5,9,10).

In an effort to delineate how we might best prevent these healthcare associated pneumonias (HCAP), regulatory and professional organizations have developed guidelines, consensus statements and practice alerts aimed at prevention (11–16). Despite these evidence-based guides to practice, ventilator associated pneumonia (VAP) still accounts for one-third of all HCAP infections and between 50%–83% of infections in the MV patient (4–7,15,17). Thus the attenuation of modifiable risk factors is an extremely important goal.

Modifiable risk factors to the aspiration of colonized organisms in the ventilated patient include such interventions as proper endotracheal tube cuff inflation (secretions that collect above the cuff of the endotracheal or trachesostomy tube and leak past the cuff into the lungs), use of continuous aspiration subglottic suctioning (CASS) tubes, decreased ventilator tubing changes, stringent hand-washing, and backrest elevation (BRE) of >30 degrees (11,13,15,18–21). Other interventions that are not as widely practiced include oral care techniques such as mouth care and oral decontamination with agents such as chlorhexidine or oral antibiotics (22–24). While selected oral care regimes are recommended for patients at risk (e.g. chlorhexidine), the evidence-based guidelines published to date do not rank them at the highest level of evidence.

As we consider the top category recommendations for prevention of VAP it is clear that clinicians closest to the patient on a daily basis play the largest role in prevention. The preventive strategies may be classified as those within the domain of a specific discipline and those that are the joint responsibility of all healthcare practitioners (Table 1). One recommendation, that of BRE, is especially noteworthy for it's applicability to the practice of all disciplines and importance in prevention of aspiration from any cause in both ventilated and non-ventilated ICU patients (19–21).

Studies and reports on healthcare initiatives designed to decrease aspiration pneumonia suggest that education of healthcare providers is the key to compliance but even with proactive training, compliance with recommendations falls far short of the goal. The purpose of this article is to focus on aspiration as it relates to the enterally fed mechanically ventilated patient. Additionally addressed are: what is known about identifying aspiration, associated risk factors, the efficacy of selected interventions aimed at prevention, and how the health care team can assure compliance.

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DETECTION OF ASPIRATION, RISK FACTORS AND THE LINK TO ENTERAL FEEDING—WHAT DO WE KNOW?

Methods to detect aspiration in enterally fed patients have included bedside assessment techniques such as gag reflex testing and bedside swallowing trials. Unfortunately, as noted by Elpern, the gag reflex does not protect the airway from aspiration; more important is the presence of an intact swallow and cough (25). Bedside swallowing tests may confirm an obvious observed aspiration and help identify potential swallowing problems but more definitive methods such as videofluroscopy and videoendoscopy are required to confirm aspiration, especially if silent. Yet, even these video-observation methods are of limited use in preventing aspiration as changes in mental status and ability to protect the airway change often in a critical care setting.

Despite demonstrated lack of specificity, commonly used bedside methods of detecting aspiration of enteral feeding include the addition of blue food dye to enteral formulas, and glucose oxidase reagent testing (25–29). If blue dye is detected in pulmonary secretions, aspiration may have occurred. However, the converse is not true; lack of the color in secretions does not rule out aspiration. The glucose testing method is based on the premise that enteral formulas have more glucose than the glucose concentration of normal pulmonary secretions. This method falls short because the presence of blood in secretions can result in a false positive and some enteral formulas have a low glucose concentration. Further negating the clinical accuracy of these methods is the fact that not all aspirations result in pneumonia. Thus it is essential that we identify the risk factors for HCAP if we are to implement effective preventive practices.

IDENTIFYING RISK FACTORS FOR ASPIRATION—IMPORTANCE OF BACKREST ELEVATION

BRE is one of the most modifiable risk factors associated with VAP. Torres, et al demonstrated a relationship between aspiration and BRE (30). Patients requiring MV were randomly assigned to a 45-degree BRE or the supine position. After labeling gastric contents with technetium (tc)-99m sulphur colloid, radioactive counts were measured on endobronchial secretions at 30-minute intervals for a total of 5 hours. Also, samples of endobronchial secretions, gastric juices and pharyngeal contents were obtained for bacterial culture. Aspiration was significantly associated with the supine position and increased with time in that position (30). In a randomized controlled trial (RCT) Ibanez (21) demonstrated that reflux of gastric contents was significantly associated with the supine position and in a multivariate analysis Kollef (19) identified that the position was a strong independent risk factor for VAP. Semi-recumbancy (45 degrees) was also associated with less aspiration in one RCT (31), and in another, a >25% decrease in pneumonia (32). Other significant risk factors for pneumonia included enteral feeding, long duration of MV (>7 days) and decreased consciousness defined by a Glascow Coma Scale (GCS) score of <9 (32).

While the case for BRE of 45 degrees as a prevention strategy for critically ill patients appears strong, subsequent work has been done attempting to identify additional factors such as those related to enteral feedings as independent risk factors for both aspiration and subsequent pneumonia. In one retrospective descriptive study of 120 consecutive mechanically ventilated patients in a trauma critical care unit, the incidence of VAP was 16.7% (1). VAP was associated with duration of mechanical ventilation, tube feeding, trauma, and the use of histamine-2 receptor antagonists. However, the retrospective nature of the study prevented the evaluation of BRE or specifics related to enteral feeding such as gastric residual volumes (GRV). Metheny, et al prospectively studied patients in 5 ICUs over a 2-year period (3). Three hundred and sixty critically ill adult tube fed patients were followed for four days and aspiration was determined by the presence of pepsin in endotracheal suctioned aspirates. At least one aspiration event was documented in 88.9% of patients and pneumonia (as determined by the Clinical Pulmonary Infection Score) increased from day one to day four (24% to 48% respectively). Significant risks for pneumonia included ICU-LOS, MV and BRE of <30 degrees. Interestingly, BRE of >30 degrees was only present in 38% of the patients. Statistically significant risks for aspiration included a BRE <30 degrees, delivery of gastric feedings, vomiting, GCS score <9, and gastroesophageal reflux disease (GERD). No association between GRV and aspiration was found. In this study, the most significant independent risk factors for pneumonia were aspiration, use of paralytics, and a high level of sedation (3).

While BRE continues to be a risk factor for all aspirations, many have questioned the potential link of aspiration to feeding tube position with or without BRE. Some study results have suggested that reflux and aspiration risk are decreased with gastric versus small bowel feeding tube placement (33–35). However, as noted by Krenitsky in a recent in-depth review of these and other existing RCTs on the topic, the findings must be cautiously interpreted (36). He notes that many of the studies were small and jejunal placement resulted in a decrease in nutrient delivery, not a decrease in the incidence of pneumonia or mortality.

Recently, McClave demonstrated that PEG tubes significantly reduced the rate of regurgitation and aspiration events versus naso-gastric tubes (20% versus 41% respectively) (37). The GRV studied were larger than most studies previously conducted. In the study 40 medical, surgical and coronary tube fed patients requiring MV were randomized to cessation of EN for GRV >400 mL (intervention) or GRV >200 mL (control). The patients were monitored every four hours for three days. Analysis of aspiration was done using fluorometry and studying tracheal oropharyngeal samples. Detection of aspiration was verified if a yellow color was noted (they put yellow microscopic beads and blue food coloring into the EN). There were no differences in aspiration between groups and the authors were unable to detect a specific GRV as a risk factor for aspiration. As in other studies (38), blue food dye did not predict aspiration. Unfortunately, BRE was not defined in the McClave study, thus making it difficult to determine the role BRE may have played in the low-risk of aspiration despite the volume of residual gastric contents (37).

When we evaluate what relationships do exist related to GRV and aspiration, it is interesting that no specific GRV threshold has been associated with aspiration events except when preceded by vomiting (39). Vomiting has been associated with aspiration in other studies as well but not GRV; in the study by Metheny described earlier, the GRVs were small and unlikely to be problematic (3). However, practices vary widely in terms of the measurement of GRV and thresholds for stopping EN infusions. Unfortunately, most clinical recommendations for stopping EN based on GRV have been lacking in evidence to support the recommendation. In the author's experience, they vary widely, from "50 mL," "double the infusion rate" to "200 mL–500 mL" and no evidence of discomfort." It has also been recognized that by stopping EN for selected arbitrary GRV's, nutrition goals are significantly reduced (36,37,40).

The studies on the topic of VAP to date suggest that significant risks of aspiration are associated with intubation and mechanical ventilation, decreased mental status and sedation (which is often the reason for decreased sensorium in this patient population), chemical paralysis, and vomiting. To date, GRVs have not been associated with aspiration in any studies on the topic. It stands to reason then, as noted by Krenitsky, McClave and Parrish, that a trend of increasing GRV may herald the need for stopping EN, but that absolute thresholds for GRV are unwarranted given the current paucity of data to guide our practice (36,37,40).

An additional related area of practice is that of the timing of extubation and the discontinuance of EN. While premature extubation requiring reintubation is associated with aspiration pneumonia (11), no studies relate GRV to same. Practice patterns vary and no consensus exists related to when EN should be discontinued as a precautionary measure. It seems prudent to consider stopping EN 1–2 hours before extubation to allow the GRV to decrease. Every effort should be made to enhance stomach emptying with techniques known to do so—such as turning the patient on his or her right side for 15–20 minutes. If necessary, the stomach contents might also be aspirated prior to extubation. It is rarely necessary to "hold" EN for extended lengths of time and in fact may be detrimental, both disallowing nutrition delivery and potentially dropping blood glucose.

While no single initiative to decrease aspiration risk in critically ill enterally fed patients is the panacea for prevention of HCAP, patient positioning is one for which all healthcare providers can, and should be, responsible.

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ADHERENCE TO BODY POSITION— HOW WELL DO WE DO?

Though a BRE of <30 degrees is consistently and strongly associated with aspiration, the seemingly simple intervention is not easy to accomplish. BRE of 45 degrees has been advocated, yet studies on compliance note that it is not a standard practice. Evans observed that the mean BRE in 113 critically ill patients was 23 degrees and that the position decreased with increasing severity of illness as defined by APACHE II score (41). Grap, et al monitored 347 measurements of BRE in 52 medical ICU patients (42). The authors sought to determine the relationship of EN and hemodynamic stability to adherence with BRE. They found that BRE of >30 degrees was rarely achieved (72% of those studied were between 0 and 30 degrees) and that elevation was not associated with EN or hemodynamic status (42). These authors subsequently studied 150 patients (506 observations) in medical, surgical and neurological ICUs to determine predictors of BRE (43). They randomly collected data over a 6-week period of time. Results demonstrated that mean BRE was 19.2 degrees and that 70% of patients were supine (no difference between units was found). Significant differences between BRE and BP measurements were demonstrated (but only seven of the patients had systolic BPs less than 90 mmHg) and no differences were noted between those receiving EN versus those not being fed. While not statistically significant, they found that intubated patients were maintained in lower positions than non-intubated patients (17% versus 23% respectively) (43).

In two interesting studies looking at nurses' ability to estimate BRE accurately, Dillon found that critical care nurses consistently over-estimated the BRE level (44) yet Hanneman found that nurses self-reporting of BRE was consistent with observed levels of 28 degrees for intubated patients (45). In both instances, the actual BRE levels fell far short of the recommended 45 degrees regardless of perceptions.

Recently, a prospective multicenter study of ventilated patients randomly assigned to the semi-recumbent position with a target BRE of 45 degrees, or standard care with BRE of 10 degrees, was conducted (46). The investigators continuously measured the total time in the position automatically. The target BRE in the intervention group was not reached 85% of the time (BRE mean = 28–22 degrees on days 1 and 7 respectively). In the standard group, the BRE rose from 9.8 to 16.1 degrees on study days 1 and 7 respectively. Of interest, the overall rates of VAP were low (6.5 and 10.7% in the two groups) (46). While other interventions aimed at decreasing VAP were not cataloged in the study, it is of interest that even with the lower BRE levels, the VAP incidence was lower than prevalence rates cited earlier. Certainly this finding makes us question whether a lower position might be equally as effective as the 30 to 45 degrees so often cited as necessary to prevent aspiration. To date, a comparison of a range of BRE levels has not been done.

Some have questioned whether perceptions of the need for BRE influence practice. To that end, a qualitative study of 93 ICU bedside nurses, nutritionists, physical therapists, residents, fellows and intensivists was conducted (47). Results demonstrated that intensivists and nutritionists were familiar with the need for semi-recumbancy versus the supine position in comparison to other health care workers. Intensivists viewed nursing preferences as the main barrier to the non-compliance with BRE. In contrast, nurses viewed physician orders as the major deterrent. Other identified barriers were alternative positions (e.g. lateral rotation), hemodynamic instability, fear of ulcer formation and shearing stress with positioning, safety (e.g. sliding out of bed) and available resources (e.g. bed types etc) (47).

In a descriptive study, 110 nurses were interviewed to assess adherence with non-pharmacologic evidence-based guidelines for preventing VAP and to identify barriers to adherence (48). The results were compared to previously reported results of a similar survey given to physicians (49). Nurses reported different levels of adherence than physicians for non-pharmacologic interventions. Most were related to patient issues, such as discomfort and fear of adverse events, whereas physicians were more related to guideline related barriers and disagreement in the interpretation of trial results (49).

Initiatives to improve compliance have focused on education and process strategies. An educational initiative for respiratory therapists and critical care nurses used an instructional module with pre- and post-testing on VAP prevention strategies such as BRE (50). In this study, VAP was reduced by 57 % following the intervention. In another study, medical and surgical ICU patients were enrolled in a prospective pre-post interventional project designed to assess the effectiveness of an intervention to improve BRE adherence (51). Interventions included a physician order set with an order for semi-recumbancy. Two months following implementation of the order sets an educational intervention was provided to nurses and physicians. BRE compliance was increased significantly ($p = 0.05$) with these interventions. The mean angle of the bed increased from 24 to 35 degrees after the order sets were initiated. Following the educational intervention the percent of those with HOB >45 degrees was 29% and mean HOB was 34 degrees (51).

From the studies done to date on adherence to BRE guidelines, a few conclusions related to compliance may be noted. The first is that adherence to a 45 degree BRE is rarely accomplished. While interviews and surveys designed to determine the reasons for non-adherence have helped elucidate some perceptions related to same (47–49), we know little about the reality of the perceived obstacles and how to offset them to improve outcomes. And, forty-five degrees is a high level of BRE and maintenance of the position is somewhat challenging, especially since patients do slide down in the bed, sometimes into positions that are undesirable regardless of the BRE.

Evans noted a relationship between BRE and APACHE II score suggesting that perhaps the patients' instability may dictate BRE (41). Anecdotally, clinicians often suggest that a lower BRE is used to enhance BP but this perception has only been tested in the studies by Grap (42,43). The investigators noted that there was a statistically significant relationship between lower BPs (albeit not clinically significant) and lower BRE. In our institution a pilot study testing this hypothesis in a thoracic cardiovascular ICU found no relationship between hemodynamic stability (defined by vasopressor use) and BRE (unpublished data, Ballew, et al 2007). Other studies testing this hypothesis would be helpful.

Another theme surrounding adherence to BRE is that all health care providers may not be aware of the necessity of BRE in the prevention of VAP. The studies on this topic suggest that for interventions aimed at improving compliance to be successful, they will likely require both educational strategies and process initiatives such as order sets (51).

Preventing aspiration in the enterally fed ventilated patient is an essential goal of care for which all healthcare team members are responsible. Backrest elevation is one of the most important interventions clinicians can make to decrease the incidence of aspiration pneumonia. While we continue to explore the role of feeding tube position and GRV to aspiration in this patient population, it is essential that we do what we can to prevent aspiration. To that end a few suggestions for practice improvement include:

1. **Assure BRE in all ventilated patients as appropriate:** educate all members of the team that they share this responsibility. Educate the team that it is not necessarily accurate to use the head of bed gauge since the gauge measures the level of the head of bed and does not measure the patient's level of BRE. For those who slide down in the bed, a technique might include elevation of the HOB to approximately 20–30 degrees, then changing the angle of the whole bed to assure BRE (i.e., reverse trendelenberg).
2. **Physician orders for BRE:** should be incorporated especially in enterally fed patients and those with decreased mental status. If not part of routine order sets, any member of the healthcare team can request such an order from the physician or nurse practitioner.
3. **Education, and re-education:** of all healthcare team members about the importance of BRE in all critically ill patients should occur frequently (at least quarterly). Repeating the information is important to assure compliance.
4. **Monitor BRE adherence:** adherence with guidelines fluctuates over time. If routine monitoring (i.e. quarterly) does not occur, you do not know if your interventions are successful!

WHAT TO DO WITH ALL THIS: A CASE FOR THE VILLAGE?

Nutritionists, nurses, respiratory therapists, physical therapists and physicians all work with the mechanically ventilated patient and share responsibility for associated outcomes. As has been discussed earlier, BRE in and of itself, appears to be clearly associated with aspiration risk with or without EN. And yet, adherence to an elevation of 45 degrees is rarely attained. With focused initiatives, 30 degrees may be more attainable, yet it is clear that not all understand the importance of this simple strategy, or how to accomplish it (52). Often BRE is considered the domain of nursing, and to a large degree this is the case, given that the nurse must weigh all aspects of the patient's condition prior to any intervention. However, when we consider the importance of such a simple intervention, the approach may be more effective if all team members assume a shared responsibility for assuring the intervention. Given the current healthcare environment, the fast pace of critical care and patient complexity, it is essential that a team approach be used. The analogy is similar to that of the pilot and co-pilot; mistakes increase (with deadly consequences) if the pilot does not heed the co-pilots concerns. Indeed, it may well take a village in this case, if we are to improve outcomes for our critically ill ventilated patients. ■

References

1. Byers JF, Sole ML. Analysis of factors related to the development of ventilator associated pneumonia: use of existing databases. *Am J Crit Care,* 2000; 9: 344-349.
2. Chastre J, Fagon JY. Ventilator-associated pneumonia. *Am J Respr Crit Care Med,* 2002; 165:867-903.
3. Metheny NA, Clouse RE, Chang Y, et al. Tracheobronchial aspiration of gastric contents in critically ill tube-fed patients: frequency, outcomes and risk factors. *Crit Care Med,* 2006;34:1007-1015.
4. Hospital Infections Program, National Center for Infectious Diseases, CDC. Public health focus: surveillance, prevention and control of nosocomial pneumonia. *MMWR. Morb Mortal Wkly Rep,* 1992;41:783-787.
5. Fagon J, Chastre J, Vuagnat A, et al. Nosocomial pneumonia and mortality among patients in intensive care units. *JAMA*, 1996;275:866-869.
6. Shorr AF, Kollef MH. Ventilator-associated pneumonia: insights from recent clinical trials. *Chest*, 2005;128:583-591.
7. Kollef MH, Shorr A, Tabak YP, et al. Epidemiology and Outcomes of health-care-associated pneumonia: results from a large US database of a culture-positive pneumonia. *Chest*, 2005;128: 3854-3862.
8. Hubmayr RD. Consensus Conference: Statement of the 4th international consensus conference in critical care on ICU-acquired pneumonia-Chicago, Illinois, May 2002. Intensive Care Medicine. Published online: 8 October 2002. http://www.springerlink.com/content/9pjhjtq1lml57yvl/
9. Warren DK, Shukla SJ, Olsen MA et al. Outcome and attributable cost of ventilator-associated pneumonia among intensive care unit patients in a suburban medical center. *Crit Care Med,* 2003;31:1312-1317.
10. Heyland DK, Cook DJ, Griffith LE, et al. The attributable morbidity and mortality of ventilator associated pneumonia in the critically ill patient: the Canadian Critical Care Trials Group. *Am J Respir Crit Care Med,* 1999;159:1249-1256.
11. Tablan OC, Anderson LJ, Besser R, et al. Guidelines for Preventing Health-Care—Associated Pneumonia, 2003 Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee March 26, 2004 / 53(RR03);1-36. (http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5303a1.htm)
12. McClave SA, DeMeo MT. Proceedings to the North American Summit on Aspiration in the critically ill patient: Consensus statement. *J Parent Ent Nut,* 2002;26(6, Suppl):580-585.
13. American Association of Critical-Care Nurses. AACN practice alert: ventilator-associated pneumonia. 2004. Available at: http://www.aacn.org/AACN/practiceAlert.
14. Seckel M. Implementing evidence–based practice guidelines to minimize ventilator-associated pneumonia. *AACN News,* 2007;24:8-10.
15. American Thoracic Society and the Infectious Diseases Society of America. Guidelines for the management of adults with hospital acquired, ventilator-associated and healthcare associated pneumonia. *Am Rev Respir Crit Care Med,* 2005;171:388-416.
16. Dodek P, Keenan S, Cook D, et al for the Canadian Critical Care Trials Group and the Canadian Critical Care Society. *Ann Intern Med,* 2004;141:305-313.
17. Vincent JL, Bihari DJ. Suter PM, et al. The prevalence of nosocomial pneumonia in intensive care units in Europe (EPIC). *JAMA*, 1995;274:639-644.
18. Bonten MJ, Kollef MH, Hall JB. Risk factors for ventilator-associated pneumonia: from epidemiology to patient management. *Clin Infect Dis,* 2004;38:1141-1149.
19. Kollef M. Ventilator–associated pneumonia: a multivariate analysis. *JAMA*, 1993;270: 1965-1970.
20. Craven DE, Kunches LM, Kilinsky V, et al. Risk factors for pneumonia and fatality in patients receiving continuous mechanical ventilation. *Am Rev Respir Dis,* 1986;133:792-796.
21. Ibanez J, Penafiel A, Raurich JM, et al. Gastroesophageal reflux in intubated patients receiving enteral nutrition: effect of supine and semi-recumbent positions. *J Parenter Enteral Nutr,* 1992;16:419-422.
22. van Nieuwenhoven CA, Buskens E, Bergmans DC, et al. Oral decontamination is cost-saving in the prevention of ventilator-associated pneumonia in intensive care units. *Crit Care Med,* 2004;32:126-130.
23. Camus C, Bellissant E, Sebille V, et al. Prevention of acquired infections in intubated patients with the combination of two decontamination regimens. *Crit Care Med,* 2005;33: 307-314.
24. Koeman M, vander Ven AJAM, Hak E, et al. Oral decontamination with chlorhexidine reduces the incidence of ventilator-associated pneumonia. *Am J Respir Crit Care Med,* 2006;173:1348-1355.
25. Elpern EH. Pulmonary Aspiration in Hospitalized Adults. *Nutr Clin Pract,* 1997;12:5-13.
26. Metheny NA, Aud MA, Wunderlich RJ. A survey of bedside methods used to detect pulmonary aspiration of enteral formula in intubated tube-fed patients. *Am J Crit Care,* 1999;8:160-169.
27. Metheny NA, Dahms TE, Stewart BJ, et al. Efficacy of dye-stained enteral formula in detecting pulmonary aspiration. *Chest*, 2002;121:1-6.
28. Metheny NA, Dahms TE, Stewart BJ, et al. Verification of inefficacy of the glucose method in detecting aspiration associated with tube feedings. *Med Surg Nursing,* 2005; 14;112-121.
29. Potts RG, Zaroukian MH, Guerrero PA, et al. Comparison of blue

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food dye visualization and glucose oxidase test strip methods for detecting pulmonary aspiration of enteral feedings in intubated adults. *Chest*, 1993;103:117-121.
30. Torres A, Serra-Batlles J, Ros E, et al. Pulmonary aspiration of gastric contents in patients receiving mechanical ventilation: the effect of body position. *Ann Int Med,* 1992; 116:540-543.
31. Orozco-Levi M, Torres A, Ferrer M, et al. Semi-recumbent position protects from pulmonary aspiration but not completely from gastroesophageal reflux in mechanically ventilated patients. *Am J Respir Crit Care Med,* 1995;152:1387-1390.
32. Drackulovic MB, Torres A, Bauer TT, et al. Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: a randomised trial. *Lancet*, 1999;354:1851-1858.
33. Fay DE, Poplausky M, Gruber M, et al. Long-term enteral feeding: a retrospective comparison of delivery via percutaneous endoscopic gastrostomy and nasoenteric tubes. *Am J Gastroenterol,* 1991;86:1604-1609.
34. Lien HC, Chang CS, Chen GH. Can percutaneous endoscopic jejunostomy prevent gastroesophageal reflux in patient with preexisting esophagitis? *Am J Gastroenterol,* 2000;95:3439-3443.
35. Heyland DK, Drover JW, MacDonald S, et al. Effect of postpyloric feeding on gastroesophageal regurgitation and pulmonary microaspiration: results of a randomized controlled trial. *Crit Care Med,* 2001;29:1495-1501.
36. Krenitsky J. Gastric versus jejunal feeding: evidence or emotion? *Pract Gastroenterol,* 2006; 42: 46-65.
37. McClave SA, Lukan JK, Stefater JA, et al. Poor validity of residual volumes as a marker for risk of aspiration in critically ill patients. *Crit Care Med,* 2005; 33: 324-330.
38. Metheny NA, Dahms TE, Stewart BJ, et al. Efficacy of dye-stained enteral formula for detecting pulmonary aspiration. *Chest*, 2002;122:276-281.
39. Mentec H, Dupont H, Bocchetti M, et al. Upper digestive intolerance during enteral nutrition in critically ill patients: frequency, risk factors, and complications. *Crit Care Med,* 2001;29:1955-1961.
40. Parrish CR, Krenitsky J, Willcutts K. Nutrition Support for the Mechanically Ventilated Patient. In *AACN Protocols for Practice: Care of the Mechanically Ventilated Patient,* 2nd Ed. Burns SM (editor); Jones and Bartlett Publishers 2006:193-252.
41. Evans D. The use of position during critical illness: current practice and review of the literature. *Australian Crit Care,* 1994; 7:16-21.
42. Grap MJ, Cantley M, Munro CL, et al. Use of backrest elevation in critical care: a pilot study. *Am J Crit Care,* 1999;8:475-480.
43. Grap MJ, Munro CL, Bryant S, et al. Predictors of backrest elevation in critical care. *Int Crit Care Nurs,* 2003;19:68-74.
44. Dillon A, Munro CL, Grap MJ. Nurses' accuracy in estimating backrest elevation. *Am J Crit Care,* 2002; 11: 34-37.
45. Hanneman SK, Gusick GM. Frequency of oral care and positioning of patients in critical care: a replication study. *Am J Crit Care,* 2005;14:378-387.
46. van Neiuwenhoven CA, Vandenbroucke-Grauls C, van Tiel FH, et al. Feasibility and effects of the semirecumbant position to prevent ventilator associated pneumonia: a randomized study. *Crit Care Med,* 2006;34:396-402.
47. Cook DJ, Meade MO, Hand LE, et al. Toward understanding evidence uptake: semirecumbancy for pneumonia prevention. *Crit Care Med,* 2002;30:1472-1477.
48. Ricart M, Lorente C, Diaz E, et al. Nursing adherence with evidence-based guidelines for preventing ventilator-associated pneumonia. *Crit Care Med,* 2003;31:2693-2696.
49. Rello J, Lorente C, Body M, et al. Why physicians do not follow evidence-based guidelines for preventing ventilator-associated pneumonia ? A survey based on the opinions of an international panel of intensivists. *Chest*, 2002;121:1-6.
50. Zack JE, GarrisonT, Trovillion E, et al. Effect of an education program aimed at reducing the occurrence of ventilator-associated pneumonia. *Crit Care Med,* 2002;30:2407-2412.
51. Helman DL, Sherner JH, Fitzpatrick TM, et al. Effect of standardized orders and provider education on head-of-bed positioning in mechanically ventilated patients. *Crit Care Med,* 2003;31:2285-2290.
52. Marshall AP, West SH. Enteral feeding in the critically ill: are nursing practices contributing to hypocaloric feeding? *Int Crit Care Nurs,* 2006;22(2):95-105.