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In Reply:—We will like to thank Woehlck *et al.* for their interesting and relevant comments on our assessment of the association between body mass index and a difficult tracheal intubation (DTI).[1] We consider the ponderal index (PI) as an operational measurement for obesity, which may be usable in a clinical context as a possible bedside test for predicting a DTI. We performed a preliminary multivariate regression analysis to determine if it is possible to include both body mass index and PI in the same model. This analysis left PI as the only independent significant risk factor for DTI, suggesting that PI may be a better predictor of DTI than body mass index. Nevertheless, the association between PI and DTI was only marginal stronger than between body mass index and DTI. We report this preliminary result with certain reservations, as it may depend heavily on the stratification of the PI,[2,3] which is by no means straightforward, as the cutoff value is not naturally given. Furthermore, our preliminary analysis suggests only marginal benefits as to the prognostic accuracy, with PI dichotomized at 25. To determine if a more clinically relevant and statistically significant relationship between the PI and DTI exists, more comprehensive and profound analyses with relevant model control are necessary. Therefore, based on our cohort, we may be able to present a more thorough assessment of this topic in the future.

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Ventilator-associated Pneumonia or Endotracheal Tube-associated Pneumonia or None of the Above? Lessons Learned from Laboratory Animal Studies

To the Editor:—We wish to address the now almost universally accepted notion, well summarized in a recent manuscript "Ventilator-associated Pneumonia or Endotracheal Tube-associated Pneumonia: An Approach to the Pathogenesis and Preventive Strategies Emphasizing the Importance of the Endotracheal Tube" by Pneumatikos *et al.*[1]

The authors emphasize that "The accumulation of contaminated secretions from oropharynx or gastrointestinal tract in the subglottic space is a crucial event in the pathogenesis of VAP [ventilator-associated pneumonia]." Hence, the authors' center of attention is directed to the pooled secretions around the cuff; they believe that "an important preventive strategy should focus on blocking up the leakage of subglottic secretions around the cuff (between ETT [endotrachial tube] and tracheal mucosa), drainage of secretions from subglottic space, and decontamination of the subglottic secretions;" while patient position has no impact on the incidence of ventilator-associated pneumonia, as it is not even mentioned, or alluded to.

Indeed, we have shown it is the patient position that is the *sine qua non* factor that determines the probability (yes, even certainty) of whether bacteria colonized oropharyngeal (or subglottic) contents and tracheal/lung secretions, will gravitate towards the oropharynx, and back into the lungs, with important consequences for the patient (analogous to the waste-water tubing in the sewer line). The authors are kind to cite our study in sheep, using the Mucus Shaver and Mucus Slurper which, when combined with keeping the orientation of the trachea below horizontal, prevented accumulation of secretions within the lumen of the endotracheal tube, the trachea, and the lungs, without need for conventional tracheal suction. Left unsaid, our subsequent studies showed that tilting/keeping the trachea (and sheep) below horizontal alone resulted in equally good outcome: No pneumonia, and no lung bacterial colonization.[2,3]

It is the latter observation that has consumed, over many years, most of our subsequent attention. Insufflating small tantalum discs into the trachea of sheep, beyond the tip of the endotracheal tube, has allowed us to monitor transport of so insufflated tantalum discs across and beyond the tip of the endotracheal tube and observe its travel during the course of mechanical ventilation. The results were as follows: With the sheep's body/head oriented in the semirecumbent position, mucus-tracheal contents rather rapidly gravitate towards the lungs, then enter the mainstem bronchi, and lodge at the most distal end of the bronchi.[4]

However, with the head/neck oriented horizontally/below horizontal (about 5–15 degrees), all mucus and secretions, together with the insufflated tantalum discs, exited the bronchi and the trachea, then entered the endotracheal tube, and then exited into the expiratory line water trap and not into the lungs.

In a recent prospective controlled trial, 80 intubated infants were randomized to supine position (n = 30) or to lateral position (n = 30) to keep the orientation of the neck/trachea at or below horizontal.[5] After 5 days of mechanical ventilation, tracheal cultures were positive in 26 infants (87%) in the supine position group and in 9 infants (30%) in the lateral group ($P < 0.05$). In the adult patient population, similar results have been observed (unpublished observations, Lorenzo Berra, M.D., Department of Anesthesia and Critical Care, Massachusetts General Hospital, Boston, Massachusetts, June 2009), showing feasibility of such patient management and excellent clinical outcome.

In summary, while medical devices (Mucus Shaver, Mucus Slurper, antiseptic impregnated endotracheal tubes, Hi-Lo Evac endotracheal

tubes [Tyco Healthcare UK Ltd., Gosport, United Kingdom], prototype endotracheal tube cuff, and so forth) may represent an improvement in the care of the intubated and mechanically ventilated patient, we believe that the sole factor that can avoid pneumonia in our intubated patients is keeping the orientation of the endotracheal tube below horizontal to drain outward oropharyngeal bacteria–colonized secretions that travel according to the laws of gravity.

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Endotracheal Tube-associated Pneumonia

To the Editor:—We would like to congratulate Pneumatikos *et al.* on the review article on ventilator-associated pneumonia (VAP).[1] An increased understanding of the pathogenesis and prevention of VAP has resulted in the proposal for a ventilator bundle with particular emphasis on semirecumbancy, early awakening, and liberation from mechanical ventilation.

The most common cause of VAP is clearly upper aerodigestive tract colonization, followed by pulmonary aspiration past the cuff of the endotracheal tube (ETT) or tracheostomy tube. After this, the inner lumen of the ETT develops a biofilm and the circuit becomes contaminated.[2] Microaspiration and VAP are intimately linked, and this has led to a search for improvements in the design of the traditional ETTs and tracheostomy tubes. High-volume, low-pressure cuffed ETTs came into practice in the early 1970s after the high incidence of tracheal injury related to low-volume, high-pressure cuffed ETTs. Seegobin *et al.* showed that high-volume, low-pressure cuffed tubes were completely ineffective in preventing leakage of aspirates as compared with low-volume, high-pressure tubes[3]; however, the practice could not change because low-volume, high-pressure tubes do not have the ability to control the pressure transmitted across to the tracheal wall.

Unless we can completely prevent pulmonary aspiration during mechanical ventilation, we cannot hope to prevent VAP. An engineered solution to assist clinicians in the interruption of the VAP pathogenesis pathway and facilitate a ventilator bundle is required. In short, a new design of ETT is needed.

There is such an ETT, currently approved for clinical use in Europe, called the LoTrach™ tube and cuff pressure controller.[4] The main advantage of the LoTrach™ system is the unique cuff, which has been calibrated during the manufacturing process so that the low-volume cuff will transmit a desirable tracheal wall pressure of 20-30 cm H_2O at all times. There are no folds in the cuff of the tube to allow fluid leakage, and so a 20–30 cm H_2O column of fluid can be held above the cuff. The efficacy of cuff to tracheal seal when compared with that of standard high-volume, low-pressure cuffs has been shown in a pig model, in anesthetized patients, and in critically ill patients.[5]

The LoTrach™ tube also has triple subglottic ports through which intermittent suctioning of secretions can be performed. The integrity of the cuff to tracheal seal is sufficient so that it will permit decontamination by irrigation of the entire supracuff airway with large volumes of saline.[4] The tube is flexible and has an atraumatic tip suitable for long-term intubation, and it has an inner nonstick coating to reduce secretion accumulation over time. Initial clinical data look very encouraging,[6] and we believe that United States regulatory approval is currently awaited. VAP is the leading cause of nosocomial morbidity and mortality in intensive care units, and the costs of VAP are so high that substantial additional investment in prevention makes both financial and humanitarian sense.

The ideal ETT is a worthy aspiration. It should provide a complete clinical seal to isolate the lungs, continuous cuff pressure control, effective subglottic secretion drainage, and biofilm resistance, and it should be gentle on the airway structures.

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In Reply:—We thank Drs. Berra and Kolobow and Drs. Sathishkumar and Fassl for their interest in our review.[1]

Berra and Kolobow raise the interesting question about the role of the patient position in the development of ventilator-associated pneumonia (VAP), and argue that keeping the orientation of the endotracheal tube below horizontal is the sole factor that can avoid VAP in intubated patients.

First, our review focuses on the pathogenesis and the preventive strategies of VAP, emphasizing the importance of endotracheal tube,