

Dear Editor:

My colleagues and I appreciate the thoughtful comments offered by Hsiao-Ling Chen, RN, MS and Shih-Hsin Hung, RN, MS regarding our recent publication. We agree that multiple factors affect the significance of gastric residual volumes (GRVs) in relation to risk for aspiration and aspiration-related pneumonia. Further, we acknowledge the widely varied views of what constitutes a 'high' GRV. The confusion surrounding research-based information regarding the significance of GRVs is largely due to a plethora of methodological problems, most important of which are differing definitions of aspiration and pneumonia, measurement error due to variation in feeding tubes and techniques for collecting GRVs, protocols for returning gastric aspirates after measurement, and lack of control for variables other than GRVs that can affect pulmonary outcomes. For example, in the Montejo et al. (2010) study, pulmonary aspiration was defined as being present when feed was detected in the tracheal aspirate (Montejo et al., 2010). Only one of the 322 patients in the study was reported to have aspirated; this is a much lower incidence than reported in similar clinical studies in which sensitive assays for aspiration were used (McClave et al., 2005; Heyland, Drover, MacDonald, Novak, & Lam et al., 2001; Metheny et al., 2006). For this reason, Montejo et al. (2010) chose to focus on ICU-acquired pneumonia as an outcome; although the study was randomized, no measurements of variables other than GRVs that could have affected pneumonia were reported. This is a potentially important omission because multiple factors (such as level of consciousness and head-of-bed elevation) have been shown to be major risk factors for pneumonia and could have impacted the findings (Adnet & Baud, 1996; Drakulovic et al., 1999; Cook et al., 1998).

The potential for measurement error is another issue that has made it difficult to compare findings from studies of GRVs and pulmonary outcomes. It has been demonstrated that high GRVs are more readily detected from large-bore tubes with multiple ports than from small-bore tubes with few ports. For example, a 2005 study compared the volumes of fluid that could be withdrawn from two types of tubes simultaneously present in the stomachs of 62 critically ill patients; a GRV  $\geq 150$  ml was identified in over 10% of the readings from large-diameter (14-18 French) sump tubes as compared to about 3% of the readings from 10 Fr polyurethane tubes (Metheny, Stewart, Neutzel, Oliver, & Clouse, 2005). Because tube characteristics have a significant effect on the accuracy of GRV measurements, it is difficult to evaluate findings from studies that do not account for this variable. An example of a study in which feeding tube characteristics were controlled is one reported by Mentec et al. (2001) in which 153 critically ill patients had large diameter (14 Fr) tubes. The investigators found that high GRVs (defined as 2 or more consecutive volumes between 150 ml and 500 ml, or one GRV  $\geq 500$  ml) was associated with greater risk for pneumonia. Unfortunately, the Mentec et al. (2001) study (like the Montejo et al. (2010) study) did not control for other possible causes of pneumonia.

Another variable that needs to be considered in a well controlled trial to assess the relationship between GRVs and pulmonary outcomes is how much aspirate is returned to the patient following GRV measurements. In a recent study, a group of researchers reported no difference in aspiration according to the volume of aspirate returned to patients (Juve-Udina, et al., 2009). Unfortunately, the method they used to detect aspiration (glucose content in tracheobronchial secretions) is unreliable in detecting aspiration of enteral feedings (Philips, Meguer, Redman, & Baker, 2003).

We chose to base our GRV algorithm on findings from a previous study that used a sensitive laboratory indicator for the aspiration of gastric contents (Metheny, Schallom, Oliver, & Clouse, 2008). In that study, 206 critically ill patients who received gastric feedings for 3 consecutive days were followed prospectively; aspiration in these individuals was compared according to a variety of GRV cutpoints (150 ml, 200 ml, and 250 ml). Factors included in the analyses to evaluate the relationship between GRVs and aspiration included volume of formula delivered, level of consciousness, sedation score, degree of head-of-bed elevation, severity of disease, and vomiting. While no consistent relationship was found between GRVs and aspiration, it was noted that subjects who experienced frequent aspiration over the 3-day study period had a significantly greater occurrence of 2 or more GRVs of at least 200ml and 1 or more GRVs of at least 250 ml. We chose the latter value to initiate use of our algorithm. Our recommendation to stop feedings for a  $GRV \geq 500$  ml was based on findings from the Mentec et al (2001) study. We acknowledge that these are arbitrary values, but ones that are commonly used in clinical settings. Unfortunately, we were unable to test our proposed algorithm because attending physicians chose not to comply with the use of prokinetics. Further, only 3 subjects met the inclusion criteria (one subject had nine GRVs that ranged between 300 and 700 ml, a second had two GRVs of 350 ml, and a third had one GRV of 325 ml). Obviously, this small sample was inadequate for comparison with other subjects in the study; nonetheless, it is noteworthy that their rates of aspiration ranged between 50% and 100%.

In summary, we thank Ms. Chin and Ms. Hung for their comments and agree with their conclusion that the relationship between GRVs and pulmonary outcomes is complex and affected by multiple variables. The goal of clinical trials is to identify the maximal GRV that can exist without leading to poor pulmonary outcomes. Tube characteristics are an important

consideration for such studies; for example, many patients are fed via small-diameter pliable tubes (as opposed to large diameter firm tubes) to promote comfort and reduce local tissue damage. Yet, it is known that GRVs are lower when measured from small diameter tubes. Thus, it is conceivable that GRV cutpoints need to differ according to tube characteristics. Another important variable is how much aspirate is returned to the patient following GRV measurements. Because aspiration is a serious problem in gastric-fed patients, we recommend that well-controlled, large clinical trials be conducted to determine best practices for handling GRVs. Until findings from such studies are available, an important clinical question will remain unanswered.

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