OUTCOMES ASSOCIATED WITH ENTERAL TUBE FEEDINGS IN A MEDICAL INTENSIVE CARE UNIT

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- **Background**  Underfeeding of patients reliant on enteral tube feedings most likely is due primarily to interruptions in the infusions. Strategies to improve energy intake require an understanding of such interruptions and associated outcomes.

- **Objectives**  To compare daily energy intake with goal energy intake; to ascertain frequency, duration, and reasons for interruptions in feedings; and to determine occurrences of feeding intolerance.

- **Methods**  A prospective, descriptive study of a convenience sample of patients admitted during a 3-month period to a medical intensive care unit. Patients were included who were expected to receive continuous enteral tube feedings for at least 48 hours. Patients were studied until discontinuation of feedings, discharge from the unit, or death.

- **Results**  Thirty-nine patients were studied for 276 feeding days. Patients received a mean of 64% of goal energy intake. Mean length of interruptions in feeding was 5.23 hours per patient per day. Interruptions for performance of tests and procedures accounted for 35.7% of the total cessation in feeding time. Next most time-consuming interruptions occurred with changes in body position (15%), unstable clinical conditions (13.5%), high gastric residual volume (11.5%), and nausea and vomiting (9.2%). Patients had diarrhea 105 (38%) of 276 feeding days. Gastric residual volumes exceeded 150 mL on 28 measurements in 11 patients. Five patients experienced episodes of nausea and vomiting. Four patients experienced an episode of feeding aspiration.

- **Conclusions**  Precautionary interruptions in enteral feedings to decrease presumed risk of aspiration occurred frequently and resulted in underfeeding. Episodes of vomiting and of aspiration were uncommon. (American Journal of Critical Care. 2004;13:221-227)

In critically ill patients, early and adequate enteral feeding is considered important to promote healing, decrease physiological stress, and enhance immunocompetence.7 Despite the importance of adequate energy intake, patients in intensive care units (ICUs) often receive less energy intake than desired.24 Factors that impede delivery of enteral feedings include those related to feeding intolerance (eg, vomiting) and those associated with standard nursing practices (eg, interruptions in tube feedings for changes in body position) or routine orders (eg, nothing by mouth before and after procedures). These practices are based more on tradition and opinion than on convincing evidence that instances of feeding intolerance, pulmonary aspiration, or nosocomial pneumonia are reduced. Efforts to improve delivery of adequate energy intake to patients receiving enteral tube feedings in the ICU require identification of current practices and outcomes.

We prospectively studied consecutive patients in a medical ICU who received enteral tube feedings to

- compare actual energy intake delivered with energy intake ordered to be delivered,
ascertain the frequency, duration, and reasons for interruptions of feedings, and
determine instances of feeding intolerance and complications related to feeding.

Underfeeding can be associated with adverse outcomes, and patients in intensive care units often receive less energy intake than desired.

Materials and Methods
Setting
The institutional review board at Rush University Medical Center, Chicago, Ill, approved the study and allowed enrollment of patients without written informed consent. Data collection was carried out in a 21-bed combined medical ICU–noninvasive respiratory care unit. Nonsurgical patients with acute or impending respiratory failure, sepsis and severe sepsis, circulatory shock, severe metabolic derangements, hematologic disorders, acute neurological disorders, neutropenic fever, and multiorgan failure were admitted to this unit.

Sample
Patients 18 years or older admitted during the 3-month period of data collection and ordered to receive enteral tube feedings were screened within 24 hours of admission and daily thereafter for inclusion in the study. Patients were excluded if they were unlikely to stay in the ICU for a minimum of 48 hours or if they received any oral or parenteral feedings. Individual patients were studied until discontinuation of enteral feedings, discharge from the ICU, or death.

Procedure
All patients were evaluated by a registered dietitian to determine the appropriate nutritional formula, goal for energy intake, and infusion rates. Typically, the goal for energy intake was calculated by using a goal of 126 kJ/kg per day (30 kcal/kg per day). Weight was determined by using the bed scale. If a patient’s current body weight was greater than 120% of his or her ideal body weight, adjusted body weight for calculation of energy intake was determined by using the following formula: adjusted body weight = (current body weight – ideal body weight) x 0.25 + ideal body weight. Ideal body weight was determined by using the Hamwi calculation:

- for men: 48 kg (106 lb) for the first 152 cm (5 ft) and add 2.7 kg (6 lb) for each 2.54 cm (1 in) greater than 152 cm (5 ft); and
- for women: 45 kg (100 lb) for the first 152 cm (5 ft) and add 2.3 kg (5 lb) for each 2.54 cm (1 in) greater than 152 cm (5 ft).

Feedings were started at a rate of 20 mL/h and were increased by 20 mL/h every 8 hours as tolerated. All patients were ordered to receive continuous enteral feeding infusions. Nursing policies for enteral tube feeding in place at the time of data collection are summarized in Figure 1.
Data Collection

An Acute Physiology and Chronic Health Evaluation II score was computed for each patient at the time of enrollment. Each subsequent study day, a data collector recorded for the previous 24 hours the volume of formula and total energy content infused; indicators of feeding intolerance (high gastric residual volume [GRV], diarrhea, nausea, vomiting, and aspiration); type of feeding tube in place; presence or absence of an artificial airway; and a clinical pulmonary infection score (CPIS). On a continual basis, nurses at the bedside recorded for each patient instances of feeding interruptions, noting the reason for each interruption and the length of time the feeding was stopped.

Definitions

The CPIS was designed to facilitate a diagnosis of ventilator-associated pneumonia. A score greater than 6 is suggestive of pneumonia. Diarrhea was defined as 3 or more loose stools per day or the need for a fecal incontinence collection bag. Aspiration was defined as the observed presence of feeding formula in tracheal aspirate suctioned from an artificial airway.

Data Analysis

SPSS 7.5 for Windows (SPSS Inc, Chicago, Ill) was used to perform statistical analyses. Nonparametric correlations were calculated by using the Spearman rho. P values less than .05 were considered significant.

Results

A total of 276 feeding days were evaluated in 39 patients. Most of the patients were men (54%). The mean age was 60.6 years (range 27-93 years). The mean score on the Acute Physiology and Chronic Health Evaluation II at the time of enrollment was 19.97 (range 9-33). Patients had artificial airways in place for 234 (85%) of 276 days. Orotracheal tubes were in place for 64% of feeding days and tracheostomy tubes for 36%. Large-bore nasogastric tubes were in place for 79% of feeding days, percutaneously placed gastric tubes for

Overall, patients received 64% of goal energy intake.
14%, and small-bore silastic feeding tubes for 7%. One patient had both a large-bore nasogastric tube and a percutaneous gastrostomy tube in place for 4 days.

**Actual Versus Goal Energy Intake**

Patients received a mean of 64% of goal energy intake (range 0%-108%). Figure 2 illustrates the distribution of percentage of goal energy intake infused daily. Patients received a mean of 2799 fewer kilojoules (669 fewer calories) than their daily goals.

**Interruptions in Feedings**

Mean duration of interruptions in feedings was 314 minutes (range 1-1440 minutes) or 5.23 hours per patient per day. The most frequent reason for interruption was the performance of tests and procedures, accounting for 35.7% of total feeding cessation time. The mean duration of lost feeding time when feedings were suspended for the performance of a procedure was 6.5 hours. Other reasons for interruptions are illustrated in Figure 3 and included changing the patient’s body position (15%), instability of the patient’s clinical condition (13.5%), high GRV (11.5%), nausea or vomiting (9.2%), administration of medications (7.7%), temporary loss of feeding tube access (3.4%), and aspiration (2.1%).

**Gastrointestinal Intolerance or Complications**

Diarrhea occurred in 28 of 39 patients on 105 (38%) of 276 feeding days. Feedings were not interrupted because of diarrhea. Nausea and/or vomiting occurred in 5 of 39 patients on 11 feeding days. Single episodes of aspiration were observed in 4 patients during 276 feeding days (1% of feeding days). None of the instances of feeding aspiration was associated with vomiting.

GRVs ranged from 0 to 775 mL. GRV totaled 150 mL or greater for 28 measurements in 11 (28%) of 39 patients. Three patients had a single GRV measurement of 150 mL or greater, 5 patients had 2 high GRV measurements, 2 patients had 3 high measurements, and 1 patient had 5 high GRV measurements.

Thirteen patients received prokinetic agents during the study period. These agents were administered on 70 (25%) of 276 study days. The agents used most often were metaclopramide (48 days), erythromycin (11 days), and both agents in combination (11 days).
Daily CPISs ranged from 0 to 10, with a mean score of 3.61. Scores greater than 6, suggestive of pulmonary infection, were recorded for 13 patients on 19 (7%) of 276 feeding days. No significant correlations were found between the CPIS and nausea and vomiting or high GRV. A significant correlation was found between the CPIS and tracheal intubation ($P < .001$).

A total of 14 (36%) of the study patients died in the ICU, 17 (44%) were transferred to a general medical floor, 7 (18%) were transferred to a chronic care facility, and 1 (3%) was discharged home.

**Discussion**

Underfeeding in acutely ill patients has been associated with adverse outcomes, including increased incidence of infection and longer hospitalization. The main finding in our study was consistent underfeeding of critically ill patients reliant on enteral nutritional support. Previous investigations indicated that patients rarely receive prescribed enteral feedings. In our study, the level of underfeeding compared with the goals for energy intake we used was similar to the level reported in other studies, in which 60% to 78% of the volumes ordered was actually infused.

The implications of such presumed underfeeding are not clear. The best method to determine energy requirements for patients with critical illnesses is controversial. Indirect calorimetry is thought to be superior to other methods of calculating energy requirements such as the Harris-Benedict equation or the simple formula we used. If the formula we used resulted in an overestimation of energy needs, the patients in our study were not truly underfed. Further, the potential disadvantage to patients not receiving “required” energy intake has not been established. The percentage of goal energy intake needed to produce desired outcomes (fewer infections, preserved muscle mass, enhanced wound healing) is not known. Until such questions are addressed by further study, it seems prudent to endeavor to optimize delivery of the amount of feeding formula needed to meet reasonably estimated goals for energy intake.

Our findings underscore the importance of maintaining infusions of feeding formula to improve energy intake. Our data indicate that feedings were stopped more often as a precautionary measure than because of evidence of gut intolerance. Commonly accepted indicators of gastrointestinal intolerance (high GRVs, nausea, vomiting) accounted for 21% of interruptions in feeding, whereas precautionary cessation (for test preparation, changes in body position) accounted for 51% of interruptions.

Despite widespread acceptance that feedings should be interrupted when GRVs are high, little evidence supports this practice. Although it is commonly thought that high GRVs indicate impaired gastric function and increased risk for gastroesophageal reflux and pulmonary aspiration, no data support these assumptions. In one study, continuous feedings of 80 mL/h in 10 patients with cerebrovascular accident or dementia did not raise esophageal sphincter pressure or lead to gastroesophageal reflux or aspiration. GRV as a marker of feeding intolerance was addressed in only a single study. McClave et al found fasting GRVs of up to 100 mL in healthy adults and in critically ill patients. This volume most likely represented retained endogenous gastric and salivary secretions. ICU patients who received enteral feedings infused at rates of 65 to 175 mL/h had periodic GRVs ranging from 0 to 375 mL, which were well tolerated. Higher GRVs tended to occur in the 2 to 4 hours after the initiation of feedings and decreased subsequently. In the same study, healthy adults (control subjects) who received similar feeding infusions had periodic GRVs up to 200 mL. McClave et al concluded that a GRV of 200 mL distinguished persons with normal gastric motility from persons in whom inadequate gastric emptying should be suspected. If a GRV greater than 200 mL had been the trigger for feeding cessation in our study, instances of interruptions in feeding for this reason would have dropped from 28 to 10.

A total of 3 of the 11 patients with “high” GRVs in our study had single isolated measurements of GRV greater than 150 mL. GRV typically increases and then plateaus in the 3 to 6 hours after feeding is started, and according to the recommendations of the American Gastroenterological Association, a single elevated GRV should not cause automatic cessation of feeding. A consensus statement from leading experts in enteral nutrition cautioned that GRVs are unreliable markers of feeding intolerance, that feedings should not be stopped for any GRV less than 400 mL, and that trends in GRV measurements are more important than any single measurement.

Investigations have indicated that chronic head elevation is more effective than supine positioning in reducing aspiration and nosocomial pneumonia in ICU patients. Although aspiration increased when patients were supine, the length of time a patient was kept in this position was critical in determining risk.

**Little evidence supports high gastric residual volume as a reason for interrupting feedings.**
It is questionable whether transient (<30 minutes) assumption of supine positioning increases the risk for aspiration. Temporary cessation of feeding infusions during transient changes in body position can also be unintentionally prolonged when feedings are not promptly restarted by busy ICU nurses.

The duration of fasting necessary before procedures to minimize the risk for aspiration is not known. Experts suggest that liquid feeding may be continued up to 4 hours before a procedure without increased gastric residual or incidence of vomiting. In some investigations, duodenal feeding was continued before, during, and after surgical procedures without complications. In our study, feedings were stopped at midnight for off-unit tests or procedures to be done the next day. Usually, feedings were stopped for a shorter duration for less invasive procedures performed at the bedside. Feedings often were not resumed for a considerable time after procedures or tests were completed. The mean duration of feeding cessation for tests and procedures in the study was 6.5 hours.

Only 4 instances of obvious feeding aspiration occurred in 276 feeding days. Whether the low frequency of aspiration of large volumes of feeding formula in the study was related to or independent of the degree of caution used to prevent aspiration is not known. We defined aspiration as the appearance of feeding formula in tracheal secretions, so occurrences of microaspirations of oropharyngeal or gastrointestinal contents were not assessed. No conclusions about aspiration of small volumes of feeding formula or aspiration of material other than feeding formula can be drawn.

The presence of diarrhea in a majority of patients (28 of 39 patients; 72%) underscores the common association between enteral feeding and diarrhea in critical illnesses. Diarrhea is the most common complication of feeding in critically ill patients. Diarrhea in these patients may be related less to enteral feeding than to medications or infections. Further, whether diarrhea adversely affects nutrient absorption and nutritional efficacy is not clear. In our study, the presence of diarrhea did not prompt discontinuation of feedings. If diarrhea had led to cessation of feedings, energy intake would have decreased even more.

A CPIS was calculated daily for each patient to identify patients with clinical evidence of pulmonary infections. Use of this scoring method was limited because complete data were not always available. Differential leukocyte counts were often missing, as were results of cultures of sputum or tracheal aspirates. Scores should be interpreted as indicating a suspicion of pulmonary infection. Although the numbers were small, no significant correlation was found between the CPIs and measures of gastrointestinal intolerance (nausea, vomiting, or GRV) or aspiration. This result raises questions about the validity of using these parameters as indicators of feeding intolerance and potential risk for aspiration or infection.

The ideal duration of fasting before tests and procedures in order to reduce aspiration is not known.

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The limitations of the study must be considered when evaluating our results. The data reflect practices of a single unit in a single institution. Data were collected on a convenience sample of subjects receiving enteral feedings during a limited time and may not accurately represent characteristics of or findings in a larger sample. Instances of feeding complications (vomiting, aspiration) were generally few, but feedings were never started in patients in whom feeding intolerance was considered likely, and such patients were not represented in data collection and analyses. Also, most patients in the study received gastric nutrition through large-bore feeding tubes, and the outcomes described relate to this route of feeding. Instances of feeding interruptions and the durations of the interruptions were recorded by the nurses who provided care for the patients in the study. Daily reviews by us of data recorded at the bedside indicated some underrecording of these variables. Feeding interruptions were not always documented, and, on rare occasions, data were not available for an entire shift. This occasional underreporting was substantiated when, for some patients, actual daily energy intake was less than expected when feeding interruptions were accounted for. Therefore, the number and duration of feeding disruptions were actually underestimated.

In summary, failure to meet nutritional goals in critically ill patients is common and is due in large part to interruptions in feedings. In most instances in our study, interruptions were precautionary, and validation of a reduced risk of aspiration of feeding formula is lacking. Episodes of feeding intolerance (vomiting and obvious feeding aspirations) were infrequent.
The results of studies such as this one underscore the need for attention to enteral feeding practices in critically ill patients. Current information is insufficient to guide clinical practice. Investigation is needed to answer important questions such as the following:

- What is the accuracy of methods commonly used to calculate energy requirements for patients with critical illnesses?
- How valid are indicators of gastrointestinal intolerance and aspiration risk in common use (GRV, nausea)?
- What evidence supports the widespread implementation of practices meant to limit complications of feeding (eg, discontinuation of feeding infusions for transient changes in body position, prolonged fasting before tests and procedures)?

A significant constraint in this area of investigation is lack of a specific and sensitive bedside measure of occurrences of aspiration, the most-dreaded complication of feeding. Aspirations are often clinically silent and may not be apparent even to the most experienced observer. No reliable clinical marker of aspiration is currently available.

Currently, it may be prudent for critical care practitioners to review methods of enteral feeding and consider strategies to improve patients’ energy intake. Such strategies might include establishing and implementing feeding protocols, which can increase energy intake, and recalculating infusion times in consideration of projected “down time” (eg, calculate hourly feeding infusion rates for 18 hours rather than for 24 hours, limit infusion times to hours when patients are unlikely to be out of the unit for tests or procedures). The impact of such strategies on improving energy intake should be confirmed via clinical investigation.

REFERENCES
