Effect of postpyloric feeding on gastroesophageal regurgitation and pulmonary microaspiration: Results of a randomized controlled trial

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Objective: To determine the extent to which postpyloric feeding reduces gastroesophageal regurgitation and pulmonary microaspiration in critically ill patients.

Design: Randomized trial.

Setting: A medical/surgical intensive care unit at a tertiary care hospital.

Participants: Intensive care unit patients were expected to remain ventilated >72 hrs. We excluded patients with esophageal, gastric, or small bowel surgery in the last week and patients with overt or clinically significant gastrointestinal bleeding. We studied 33 patients; 42.4% were female, mean age (so) was 59.2 (± 16.8) yrs, and mean Acute Physiology and Chronic Health Evaluation II score was 22.5 (7.8).

Interventions: Patients were randomized to gastric or postpyloric enteral feeds. Technetium 99-sulphur colloid was added to the feeds for 6 hrs of each of the first 3 days on study.

Measurements and Results: We sampled the oropharynx and trachea hourly for the 6 hrs per day that patients received radioisotope-labeled enteral feeds, and the level of radioactivity in these specimens was measured. We defined an episode of gastroesophageal regurgitation and microaspiration as an increase in radioactivity >100 counts per minute/g. Patients fed into the stomach had more episodes of gastroesophageal regurgitation (39.8% vs. 24.9%, p = 0.04) and trended toward more microaspiration (7.5% vs. 3.9%, p = 0.22) compared with patients fed beyond the pylorus. When the logarithmic mean of the radioactivity count was compared across groups, there was a trend toward an increase in gastroesophageal regurgitation (3.7 vs. 2.9 counts/g, p = 0.22) and a trend toward increased microaspiration (1.9 vs. 1.4 counts/g, p = 0.09) in patients fed into the stomach. Patients who had gastroesophageal regurgitation were much more likely to aspirate than patients who did not have gastroesophageal regurgitation (odds ratio: 3.2; 95% confidence interval: 1.36, 7.77).

Conclusions: Feeding beyond the pylorus is associated with a significant reduction in gastroesophageal regurgitation and a trend toward less microaspiration. (Crit Care Med 2001; 29:1495–1501)

Key Words: critical care; cross infection; aspiration; regurgitation; gastrointestinal motility; pneumonia; colonization; randomized trial; nutrition support

Hospital-acquired infection is a major problem for critically ill patients, resulting in increased morbidity, mortality, and healthcare costs (1–3). The overall infection rate approaches 40% and may be as high as 80% in patients admitted to the intensive care unit (ICU) for >5 days (4, 5). Pneumonia is the most frequent cause of ICU-acquired infection and significantly prolongs the stay in ICU and increases the risk of dying (4, 6).

Abnormalities of the upper gastrointestinal tract play a central role in the pathogenesis of nosocomial pneumonia in the critically ill patient. Gastric atony and the use of enteral feeds are thought to increase the risk of gastric colonization with potentially pathogenic organisms (7, 8). Gastric colonization plays a significant role in the contamination of tracheal secretions and in the development of nosocomial pneumonia (9–11). By labeling gastric contents with radioisotopes, other investigators have documented the presence of gastric contents in pulmonary sections (12–14). In addition, duodenogastric reflux (indicated by the presence of conjugated bilirubin in the stomach secretions) was shown to correlate with the isolation of Gram-negative bacteria in the stomach and the trachea in mechanically ventilated patients (15, 16).

Strategies that can reduce the amount of duodenogastric reflux, gastric colonization, gastroesophageal regurgitation, and pulmonary aspiration have the potential for reducing the burden of illness associated with nosocomial pneumonia. By delivering enteral feeds directly into the small bowel, beyond the pylorus, the risk of aspiration is thought to be decreased. However, there are no studies in critically ill patients that support this hypothesis, and recent reports in noncritically ill populations suggest that postpyloric feeding may not prevent subsequent aspiration (17–19).

The purpose of this study was to explore whether feeding beyond the stomach, into the small bowel, would result in less gastroesophageal regurgitation and pulmonary aspiration. We added technetium 99 (99Tc) to the enteral feeding
product to facilitate the detection of re-
gurgitation and aspiration.

METHODS

This study was a single-center, clinical trial
of critically ill patients randomized to receive
enteral feeds either into the stomach or be-
yond the pylorus directly into the small bowel.
Block randomization with sealed, opaque en-
velopes was used to ensure that study person-
nel were blinded to next treatment allocation.
This study occurred at the 21-bed, medical/
surgical ICU at the Kingston General Hospital,
a tertiary care unit affiliated with Queen’s Uni-
versity. The Institutional Review Board re-
viewed and approved the study protocol before
initiation of the study. Informed consent was
obtained from substitute decision makers be-
fore initiation of the study protocol.

We recruited ICU patients expected to re-
main mechanically ventilated for >72 hrs who
were eligible to be fed enterally. We excluded
patients with overt gastrointestinal bleeding, a
clinically important gastrointestinal bleed
within the last 2 wks before ICU admission,
patients with recent (<1 wk) esophageal, gas-
tric, or small bowel surgery, patients with gas-
trostomies and jejunostomies, and pregnant
patients. The following data were recorded
upon enrollment: age, sex, admission diagno-
sis, Acute Physiology and Chronic Health
Evaluation II score (20), and admission date to
hospital and to ICU.

In both groups, we attempted to initiate
study feeds within 48 hrs of admission to the
ICU. Small bowel access was achieved either
blindly or endoscopically. Position was ini-
tially confirmed with an abdominal radiograph
and subsequently whenever there was a ques-
tion about tube placement. In cases of uncer-
tainty, 50 mL of gastrografin was injected
through the feeding tube just before radiogra-
phy assessment to facilitate determination
of tip position. Jejunal feeding flushes (Abbott
Laboratories, Ross Products Division, Columbus, OH)
were used as the study feed. Determination and
documentation of energy requirements was
done by the ICU dietitian using basal energy
expenditure plus activity factors (21).

Patients in the small bowel group were fed
with a 12-Fr feeding tube placed beyond the
pylorus. No attempt was made to place the
tube specifically into the jejunum. These pa-
thems also had a gastric tube (14, 16, or 18 Fr)
for sampling and draining stomach contents.
In the gastric group, patients had both a
small-bore feeding tube and a large-bore tube
for drainage and sampling. All tubes placed in
the stomach were placed through the nose or
the mouth using standard procedure by the
ICU physician or physician’s delegate. All
study patients were fed with the head of the
bed elevated to around 30°. In both groups, we
used a standardized feeding protocol that in-
cluded initiating enteral feedings within 48
hrs of admission at 25 mL/hr and checking
gastric residuals every 4 hrs (in gastric group
only). At the end of each 4 hr interval, the feeding rate
was increased by 25 mL/hr until the
target rate was reached if the residual
volume was <200 mL. If the residual volume
was >200 mL, the feeds were held at the same
rate or the rate was reduced by 25 mL/hr.
Motility agents (cisapride or metoclopramide)
were allowed if the patient had a gastric resid-
ual volume >200 mL. In the small bowel–fed
group, gastric residuals were not checked and
nasogastric tubes were placed on continuous
low wall suction or straight drainage. Patients
were monitored daily for abdominal disten-
sion, pain, nausea and vomiting, diarrhea, or
constipation.

All study patients received radiolabeled en-
teral feeds to facilitate detection of gastro-
-esophageal regurgitation and pulmonary aspi-
ration. 99Tc-sulphur colloid (1 mCi/patient/
study day) was added to study feeds for first 3
days of study only.

On the days of administration of the radio-
isootope, the rate of enteral feeding at 0900 hrs,
on each test day, was used to calculate the
projected volume of feeds to run at a constant
infusion over the next 6 hrs. Jejunal feeds and 1
mCi of 99Tc-sulphur colloid were then placed
into a new feeding bag and radiolabeled feeds
were initiated. No changes to the feeding rate
were made during the study interval; gastric
residuals were not checked. During this 6-hr
period, regular sampling of gastric, orophary-
ngeal, and tracheal secretions occurred (see
below). After the radiolabeled feeds were in-
fused (at a constant rate to ensure delivery of
1 mCi 99Tc-sulphur colloid over 6 hrs), the
soiled enteral feeding delivery system was
changed and the rate of feeding was increased
as per usual protocol. The following day, for
up to a maximum of 3 days, the administration
of radiolabeled feeds and subsequent sampling
repeated as above. Patients in either the gas-
tric- or small bowel–fed groups, who required
that their radiolabeled feeds be held or discon-
tinued during any of the three potential 6-hr
test periods were dropped from further evalu-
ation. Patients received study feeds for the
three study days as long as it was clinically
indicated. After the 3-day study periods, deci-
sions about enteral nutrition were left with the
attending staff.

Measurements. The primary outcome
measures for this study were gastroesophageal
regurgitation and pulmonary aspiration. Sec-
ondary outcomes included gastric pH and
duodenogastric reflux.

To detect regurgitation and aspiration in
those patients who received radiolabeled feeds,
the oropharynx and endotracheal tube were
suctioned at baseline (time 0) and 60, 120,
240, 300, and 360 mins after initiation of ra-
diolabeled feeds. Separate 10-Fr Meditron
(Terrebonne, Quebec, Canada) aspiration
catheters were placed into the posterior oro-
pharynx and passed down the endotracheal
tube and aspirates were collected in sterile
aspiration traps. Saline was used to induce
collection of bronchial secretions when neces-
sary but the amount was kept to a minimum.
New catheters were used for each sample col-
lected to avoid cross-contamination with 99Tc-
sulphur colloid that may be adherent to the
wall of the aspiration catheter from previous
samples. At the end of each study day, samples
were taken to the nuclear medicine laboratory
where each sample of bronchial or pharyngeal
secretions was weighed (1 g = 1 mL) and
homogenized. Each sample was then placed in
a gamma counter tube where both the total
counts per minute (cpm) and the cpm/mL
were determined (corrected for decay and
baseline radioactivity). Although 99Tc-sulphur
colloid is not normally absorbed from the gas-
trointestinal tract (12, 13), 5 mL of blood were
taken at times 0 and 360 mins of each study
day to detect oral absorption of 99Tc-sulphur
colloid that might have occurred.

To detect duodenogastric reflux in those
patients receiving small bowel feeds, aspirates
of gastric contents were collected at time 0
and 60, 120, 240, 300, and 360 mins after
initiation of radiolabeled feeds. All samples
were processed and radioactivity was mea-
sured as described above. To measure the in-
fluence of route of feeding on gastric pH, na-
sogastric aspirates taken at baseline and 360
were assessed for pH using a digital pH meter.
Laboratory personnel remained blind to the
route of enteral nutrition delivery. Results of
radioactivity assessments were not released to
the attending physicians or sent to the ICU.
Because the focus on our short-term study
was on regurgitation and aspiration, we did not
report nutritional and other clinical out-
comes in study patients.

Statistical Analysis. Because we had no
previous experience with radioisotope-labeled
enteral feeds, we initiated a pilot study of 20
patients and planned an interim analysis after
20 analyzable patients. Using the observed
differences in aspiration rates between the
two groups as estimates, the interim analysis sug-
gested that we would need over 200 patients
to detect a statistically significant difference.
Given our limited funding, the study was ter-
minal after 39 patients had been enrolled.

The primary analysis examined rates of
gastroesophageal reflux and aspiration across
groups. Given that we observed some baseline
radioactivity in blood (on average, <100 cpm/
g), we considered a detection of >100 cpm/g
in a sample from the oropharynx and a sample
from the trachea as positive for gastroesopha-
geal reflux and aspiration, respectively. In ad-
dition, we reported the mean log of radioactive
cpm per specimen each day. For patients fed
into the small bowel, we measure duodenoga-
stric reflux in a similar fashion.

To compare the rates of gastroesophageal
reflux and aspiration between the gastric

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group and the small bowel group, a multiple logistic regression model was applied. The model took into account the possible differences resulting from other factors such as day-to-day differences, time differences, and possible variations resulting from different patient characteristics. Because the data were collected at six different times in the three study days for each patient, these repeated observations were not independent, especially among each of the 6-hr repeated measures. To account for this possible dependence, the first-order autoregressive correlation structure was considered and incorporated into the logistic model, and the generalized estimating equation (22) was applied to estimate the regression parameters. The adjusted odds ratios derived from the logistic regression model were reported to compare the two groups.

Alternatively, we also analyzed the data using log of radioactive cpm per specimen showing the amount of radioisotope detected as an outcome variable. Repeated measures analysis of variance (ANOVA) (23) was applied to compare the two groups. Day-to-day differences, time differences, and patient characteristics were also taken into consideration in the ANOVA model. The adjusted (least squared) means log of radioactive cpm per specimen for the two groups were derived from the ANOVA model and they were compared statistically using the usual .05 level of significance. Repeated measures ANOVA was also applied to compare gastric pH between the two groups.

Instead of comparing the two groups, we further applied the same analysis strategy and modeling to study the tube position (assigning 0 for the gastric group [stomach], 1 for the first part [proximal] duodenum, 2 for the second part [distal], 3 for the third part, and 4 for the fourth part duodenum); relate it to the reflux, regurgitation and aspiration; and to identify the possible trend that would indicate that, as the position of the feeding tube was located more distally in the small bowel, the less likely that reflux, regurgitation, and aspiration would occur.

A Fisher’s exact test was used to compare simple proportions. A p value < .05 was considered significant; no adjustment for multiple comparisons was done.

**RESULTS**

Thirty-nine critically ill patients were recruited and enrolled into this study; 21 to the gastric group, 18 to the small bowel group. Five of these patients did not actually receive radiolabeled feeds and were excluded from the analysis. In the postpyloric group, two were extubated and one died before they received feeds and a fourth did not receive feeds because there was no nuclear medicine technician available. In the gastric group, one patient was extubated before receiving feeds. In addition, there was one patient who was randomized to small bowel feeds but never achieved small bowel access. The patient was fed into the stomach and analyzed in the gastric group. Finally, before the analysis we discovered that one patient randomized to the postpyloric group had received the wrong dose of radioisotope. This patient was also excluded from the analysis. The demographic and baseline characteristics of the remaining study patients (n = 33, 21 gastric and 12 small bowel) are shown in Table 1.

**Gastroesophageal Regurgitation.** Overall, 29 (87.9%) out of 33 patients experienced at least one episode of gastroesophageal regurgitation; 17 (81%) in the gastric group vs. 12 (100%) in the postpyloric group (p = .27). No differences were found among different ages and different sexes in their reflux, regurgitation, and aspiration, so that age and sex were not considered in the logistic regression models. Factors in the final logistic models included group, patient, day, and time. Based on the logistic model, patients fed into the stomach were found to have more episodes of gastroesophageal regurgitation (39.8% vs. 24.9% with the adjusted odds ratio [OR] = 2.13, p = .04 from the logistic model) (Fig. 1). Based on the repeated measures ANOVA, the amount of radioisotope detected in the oropharynx tended to be higher in the gastric group, but the results were not statistically significant (1.9 vs. 1.4 in log counts/min/g, p = .09) (Fig. 4). As the feeding tube was placed more distally in the small bowel, there was a trend toward fewer episodes of aspiration (Table 2). Patients who had gastroesophageal regurgitation were much more likely to aspirate than patients who did not have gastroesophageal regurgitation (OR: 3.2; 95% CI: 1.36, 7.77).

**Duodenogastric Reflux.** Eleven of the 12 (92%) patients fed into the small bowel had episodes of duodenogastric reflux. Reflux was detected in 82.6% of the gastric aspirates from the group fed into the small bowel. There was no relationship between tube position in the small bowel and amount of reflux (Table 2).

Using gastric pH as outcome, the repeated measures ANOVA showed that gastric pH was significantly higher in the gastric group (5.0 vs. 4.1, p = .04). There

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Gastric</th>
<th>Postpyloric</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>21</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>56.2 (17.9)</td>
<td>64.3 (13.83)</td>
<td>59.2 (16.8)</td>
</tr>
<tr>
<td>Female, %</td>
<td>33.3</td>
<td>58.3</td>
<td>42.4</td>
</tr>
<tr>
<td>Admission diagnosis (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac</td>
<td>3 (14.3)</td>
<td>4 (33.3)</td>
<td>7 (21.2)</td>
</tr>
<tr>
<td>Respiratory</td>
<td>8 (38.1)</td>
<td>0 (0.0)</td>
<td>8 (24.3)</td>
</tr>
<tr>
<td>Neurologic</td>
<td>3 (14.3)</td>
<td>1 (8.3)</td>
<td>4 (11.5)</td>
</tr>
<tr>
<td>Sepsis</td>
<td>0 (0.0)</td>
<td>2 (16.7)</td>
<td>2 (6.1)</td>
</tr>
<tr>
<td>Trauma</td>
<td>3 (14.3)</td>
<td>3 (25)</td>
<td>6 (18.1)</td>
</tr>
<tr>
<td>Surgical</td>
<td>3 (14.3)</td>
<td>2 (16.7)</td>
<td>5 (15.2)</td>
</tr>
<tr>
<td>Other</td>
<td>1 (4.8)</td>
<td>0 (0.0)</td>
<td>1 (3.0)</td>
</tr>
<tr>
<td>Mean APACHE II (SD)</td>
<td>22.7 (7.5)</td>
<td>22.1 (8.5)</td>
<td>22.5 (7.8)</td>
</tr>
<tr>
<td>Total no. of patients with comorbid illness</td>
<td>13</td>
<td>10</td>
<td>23</td>
</tr>
<tr>
<td>Total no. of patients receiving motility agents</td>
<td>14</td>
<td>4*</td>
<td>23</td>
</tr>
</tbody>
</table>

*Cisapride* | 11 | 0 | 11
*Metoclopramide* | 1 | 3 | 4
*Erythromycin* | 4 | 1 | 5

APACHE, Acute Physiology and Chronic Health Evaluation.

*p = .08.*
was a trend toward a lower gastric pH as the position of the feeding tube was located more distally in the small bowel ($p = .05$).

The average amount of $^{99}$Tc-sulphur colloid detected in blood at baseline was 92 counts/min. At the end of study period (360 mins later), the average amount of $^{99}$Tc-sulphur colloid detected was 129 counts/min.

**DISCUSSION**

Abnormalities in the gastrointestinal tract are causally related to infection in critical illness (12–16). To the extent that critically ill patients regurgitate and aspirate contaminated gastric contents, they may be at a higher risk for developing pneumonia (15, 16). Using a radioisotope-labeled feed, we have demonstrated that gastroesophageal regurgitation occurs commonly, and pulmonary aspiration less so, in critically ill patients. Moreover, the location of the distal tip of the feeding tube significantly influences the amount of radioactivity of these events. In the context of a randomized trial, we have demonstrated that feeding patients beyond the pylorus into the small bowel significantly reduces gastroesophageal regurgitation and tends to lower pulmonary aspiration as well. Our inability to detect a statistical difference in aspiration rates in largely because of our small sample size and because patients aspirate less than they regurgitate. In a regression model, we demonstrated that the farther down the feeding tube was positioned into the small bowel, the less gastroesophageal regurgitation and less aspiration was observed. Finally, we observed that although, overall, pulmonary aspiration occurred infrequently, patients who regurgitated were much more likely to aspirate than those who did not regurgitate.

There are several limitations to this study that limit the inferences we can draw from these findings. First, our small study limited our ability to find significant differences in study end points; many of the results were consistent with trends. Second, excluding randomized patients from the analysis increases the chance that bias may account for some of our observed findings. Lastly, the clinical significance of $>100$ counts/min of radioisotope detected in the oropharynx or trachea is unknown. These study end points are surrogate or intermediate end points, not clinically important. However, we believe

![Figure 1. The number of episodes of gastroesophageal regurgitation per day in each group displayed as a fraction. An episode of regurgitation is defined as $>100$ counts/min/g of radioisotope detected in oropharynx ($p = .04$).](image1)

![Figure 2. The amount of gastroesophageal regurgitation per day in each group ($p = .22$).](image2)

<table>
<thead>
<tr>
<th>Tube Position</th>
<th>No. of Patients</th>
<th>% Positive GER</th>
<th>% Positive Aspiration</th>
<th>% Positive Reflux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach</td>
<td>21</td>
<td>31.2</td>
<td>5.8</td>
<td>NA</td>
</tr>
<tr>
<td>D1</td>
<td>8</td>
<td>27.1</td>
<td>4.1</td>
<td>58.3</td>
</tr>
<tr>
<td>D2</td>
<td>3</td>
<td>11.1</td>
<td>1.8</td>
<td>57.4</td>
</tr>
<tr>
<td>D4</td>
<td>1</td>
<td>5.5</td>
<td>0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Reflux, duodenogastric reflux; NA, not applicable; D1, first part of duodenum; D2, second part of duodenum; D4, fourth part of the duodenum. There were no tubes in the third part of the duodenum.

$p = .004; ^bp = .09; ^c p = NS.$

Table 2. Relationship between tube position and gastroesophageal regurgitation (GER)
that there is sufficient evidence linking gastroesophageal regurgitation and pulmonary aspiration to subsequent pulmonary infection that preventing these substitute end points is worthwhile.

Pulmonary microaspiration is known to occur during sleep in healthy individuals, in noncritically ill hospitalized patients, and in intubated patients (despite the presence of a cuffed endotracheal tube) (24, 25). The true incidence and clinical sequela of microaspiration in mechanically ventilated patients is unknown, partially because of the difficulties in diagnosing microaspiration. Various methods have been used to detect microaspiration. Adding blue dye to facilitate the visual detection of feeds is perhaps the most common method, but has not been shown to be a reliable or valid measurement tool (26). Likewise, detection of glucose in tracheal secretions has been studied but not found to be valid (26). The gold standard for establishing the diagnosis of microaspiration should involve the use of nonabsorbable radioisotopes (12–14). However, the clinical significance remains uncertain. Not all patients who aspirate develop pneumonia. ICU-acquired pneumonia occurs when pathogenic organisms find their way into the lower respiratory tract (which is normally sterile) and are able to evade or overwhelm normal host defenses (mechanical, humoral, and cellular). Furthermore, as observed in our study (data not shown), there is tremendous variability in rates of aspiration within a given patient over time and across patients.

We recently demonstrated that by using a low-pH feeding formula, we could eliminate gastric colonization and significantly reduce tracheal contamination with Gram-negative bacteria (27). This was associated with a trend toward a reduction in pneumonia. Presumably, this reduction in tracheal contamination and subsequent pneumonia was mediated by reducing the amount of bacteria present in the secretions that are regurgitated and subsequently aspirated. It was noteworthy that, of the 11 organisms implicated in the etiology of the 10 cases of pneumonia, 6 first appeared in the stomach, 1 appeared in the stomach and feeding reservoir at the same time, 1 appeared in the feeding reservoir first, and 3 organisms appeared only in the lungs. Patients who were colonized in the stomach were significantly more likely to develop pneumonia than those who were not colonized in the stomach (OR: 4.2; 95% CI: 1.2–15.5).

Further support for the gastropulmonary route of infection comes from studies in which, in the multivariate regression analysis, variables related to the
stomach, such as the use of cimetidine, witnessed aspiration, and nasogastric tubes, are significantly associated with the development of pneumonia (28–30). In addition, studies that examine the role of gastrointestinal dysmotility, gastrolesophageal regurgitation, and pulmonary aspiration of gastric contents provide additional support for the gastropulmonary route of infection. Gastric atony and duodenogastric reflux (indicated by the presence of conjugated bilirubin in the stomach secretions) has been shown to correlate with the isolation of Gram-negative bacteria in the stomach and the trachea in mechanically ventilated patients (7, 16). By labeling gastric contents with radioisotopes, other investigators have documented the presence of gastric contents in pulmonary sections (12–14). Rates of gastrolesophageal regurgitation and aspiration are increased in the supine position and by the presence of a nasogastric tube whereas the semirecumbent position has been shown to reduce regurgitation of gastric contents (12–14). Furthermore, in a randomized trial of mechanically ventilated patients, elevating the head of the bed to 45° was associated with a significant reduction in pneumonia (both clinically and bronchoscopically diagnosed) compared with for patients treated in the supine position (31). If elevating the head of the bed reduces pneumonia, by way of reducing gastrolesophageal regurgitation and pulmonary aspiration, it is plausible that distal small bowel feeding could do likewise.

There are three published randomized trials that have attempted to measure such an effect. Montecalvo (32) compared intragastric feeds to endoscopically placed jejunal feeds in 38 critically ill patients. There were two patients in the gastric-fed group that developed pneumonia; none in the jejunal group although the results were not statistically significant. Kearns et al. (33) investigated the rate of ventilator-acquired pneumonia in a small study of 44 mechanically ventilated patients requiring enteral nutrition randomized to gastric or small bowel feeding. Only four patients in the small bowel group and three in the group fed into the stomach develop pneumonia (p = .90). Finally, Kortbeek and colleagues (34) randomized 80 trauma patients to gastric or small bowel feeding. More patients fed into the stomach developed pneumonia than patients fed into the small bowel (42% vs. 27%) although the results were not statistically significant (absolute risk difference 15%; 95% CI: −5.4, 35.4). Overall, these studies have been too small and underpowered to detect a significant treatment effect with distal small bowel feedings. Given that patients fed into the small bowel still reflux into the stomach and the further the tip is located into the distal small bowel, the more one can reduce regurgitation and aspiration, future randomized trials of small bowel feedings should ensure the tip is located beyond the ligament of Treitz. This would optimize the study design to detect a difference in rates of pneumonia.

In summary, we have shown that feeding beyond the pylorus is associated with a significant reduction in gastrolesophageal regurgitation and a trend toward less pulmonary microaspiration. Given the extent to which gastric colonization, duodenogastric reflux, gastrolesophageal regurgitation, and pulmonary microaspiration are linked with subsequent pulmonary infection in critically ill patients, we conclude that it is plausible, that by feeding in the distal small bowel, we may be able to prevent subsequent pulmonary infection in this high-risk patient population.

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REFERENCES


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**Project IMPACT, Version 3.0, Released March 2001**

In the first quarter of 2001, Project IMPACT (PI) has trained and certified more than 100 PI Clinical Abstract Specialists in preparation for their transition to PI User 3.0 software, released in March. 3.0 includes a greatly revised and improved data set and user software. Some of the new enhancements include the following:

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