The pH of Feeding Tube Aspirates from Critically Ill Infants

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Background
The extent to which gastric acid inhibitors and feedings affect gastric pH in infants is unclear.

Objectives
To compare pH values of gastric aspirates from infants according to use or no use of gastric acid inhibitors and feedings.

Methods
Colorimetric pH tests were used to measure the pH of aspirates from feeding tubes in 54 critically ill infants; 29 of the gastric aspirates were from infants who did not receive acid inhibitors or feedings, 13 were from infants who received acid inhibitors but no feedings, 3 were from infants who received feedings but no acid inhibitors, and 5 were from infants who received both acid inhibitors and feedings. The remaining 4 feeding tubes were in nongastric sites.

Results
Individual pH readings of 5.5 or less were found in 97% of the gastric aspirates from infants with no recent feedings or acid inhibitors, 77% of the gastric aspirates from infants who received acid inhibitors, and 67% of the gastric aspirates from infants with recent feedings. Among 2 esophageal aspirates and 2 duodenal aspirates, 1 of each type had a pH less than 5.5. A pH cut point of 5.5 or less did not rule out esophageal or duodenal placement.

Conclusions
The pH of gastric aspirates from critically ill infants is often 5.5 or less, regardless of the use of acid inhibitors, feedings, or both. Most likely a cut point of 5.5 or less would rule out respiratory placement because tracheal pH is typically 6.0 or higher. (American Journal of Critical Care. 2015;24:e72-e77)
Radiography is the most accurate method for distinguishing between gastric and respiratory placement of blindly inserted nasogastric tubes; however, clinicians are reluctant to obtain radiographs for this purpose in infants for fear of excessive cumulative exposure to radiation and radiation injury. Thus, bedside tests are especially important in these patients. Testing the pH of feeding tube aspirates is frequently recommended but infrequently used. Probable reasons for the lack of use are concerns that an infant’s developmental age and the frequent use of feedings and gastric acid inhibitors interfere with the effectiveness of pH testing. However, the extent to which these factors actually influence the efficacy of this method in infants is unknown because little research has been focused on these patients.

### Background

#### Developmental Age

Preterm and term infants in the early weeks of life have a weaker acid secretory response than do older infants and adults. However, evidence indicates that all infants, including premature infants as young as 24 weeks’ gestational age, can maintain an intragastric pH less than 4 from the first day of life. In a clinical study of 645 tube-fed children in which the median age was 1 year, Gilbertson et al reported that infants younger than 1 year had a higher mean gastric pH (4.01; SD, 1.5) than did children 1 year and older (3.3; SD, 1.4). Discerning the importance of this finding is difficult because Gilbertson et al did not control for recent feedings and the use of gastric acid inhibitors when making this comparison. Because of confusion about typical gastric pH values in infants, clinicians caring for infants are unsure about a suitable pH cut point to indicate accurate placement of feeding tubes.

#### Gastric Acid Inhibiting Agents

Although the aim of gastric acid inhibitors is to raise gastric pH to greater than 4, evidence has indicated that the inhibitors do not consistently achieve this purpose because of variations in dosages and administration schedules. For example, using continuous gastric pH measurements in 21 fasting infants, Kierkus et al found that high-dose pantoprazole (compared with low-dose pantoprazole) resulted in a higher percentage of time that the pH reading was greater than 4. In a study of 645 tube-fed children (age 0.3-5.2 years), the percentage of gastric aspirates with pH values greater than 4 was higher in children who received gastric acid inhibitors (44.9%) than in those who did not (25.9%).

#### Frequent Feedings

Because milk has a neutral pH and can buffer acid, the pH of gastric contents after milk feedings is elevated for 1 to 2 hours. Thus, because infants receive frequent feedings, their gastric pH may be greater than 4 for prolonged periods. Nonetheless, studies suggest that gastric pH may decrease to less than 4 between feedings in bolus-fed infants. We found no studies on the gastric pH of infants who received continuous gastric feedings.

### Purpose of the Study

Information on factors that can affect the effectiveness of pH testing in determining placement of feeding tubes in infants is limited. Our study is intended to provide data to help clinicians recognize typical pH values of gastric aspirates from infants who have (or have not) received gastric acid inhibitors or recent feedings.

### Objectives

This study was designed to determine the pH of aspirates from the nasogastric feeding tubes of critically ill infants, compare the pH of the gastric aspirates according to use or no use of gastric acid inhibitors, use or no use of recent feedings.
and combined use of gastric acid inhibitors and recent feedings with the pH of gastric aspirates from infants who had neither treatment.

Methods
This prospective descriptive study was approved by the Wayne State University, Detroit, Michigan, institutional review board before data collection began. Waiving of parental consent was granted because risk to the infants was considered minimal.

Sample
A single aspirate was collected from each infant in a convenience sample of 54 critically ill infants who had nasally inserted feeding tubes intended for gastric feedings (Table 1). All dosages of gastric acid inhibitors were based on the infant’s body weight and route of administration.

Data Collection
In the pediatric intensive care unit, 1 of 2 pediatric nurse practitioners withdrew aspirates from the feeding tubes of the 54 critically ill infants within 60 minutes of a radiograph obtained for reasons unrelated to this study. All of the infants had radiographs; in addition, the reporting radiologists provided descriptions of the feeding tubes’ locations.

Measurements
Two colorimetric pH tests were used to increase the reliability of the pH measurements of the feeding tube aspirates. First, in order to determine the approximate pH of an aspirate, a drop of the aspirate was placed on pH paper calibrated in units of 1 (Hydrion 0-14, Micro Essential Laboratory Inc). A second colorimetric pH indicator was used to determine more definitively the pH of each aspirate. If the reading from the first test was 5 or less, a drop of the aspirate was placed on colorimetric pH paper calibrated in increments of 0.2 to 0.3 units (Hydrion Microfine 4.9-6.9, Micro Essential Laboratory Inc). Results from the second pH paper were used for data reporting and statistical comparisons. The 2 pediatric nurse practitioners who collected the data performed all of the pH measurements.

Statistical Analysis
Means and standard deviations were used to describe continuous data. Absolute counts and percentages were used for categorical data. Data were analyzed by using independent t tests, Mann-Whitney tests, and Pearson correlations. P values less than .05 were considered statistically significant. For comparisons of gastric aspirate pH values according to treatment status, the aspirates were divided into 4 categories according to use or no use of gastric acid inhibitors and use or no use of recent gastric feedings: category 1, no use of gastric acid inhibitors and no recent feeding; category 2, use of a gastric acid inhibitor; category 3, a recent feeding; and category 4, use of a gastric acid inhibitor and a recent feeding.

Category 1 was used as the control group for comparisons with categories 2, 3, and 4.

Table 1
Summary of demographic and clinical data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Valuea</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>54</td>
</tr>
<tr>
<td>Age, mean (SD), range, weeks</td>
<td>16.2 (14.9), 0.5-50</td>
</tr>
<tr>
<td>Gestational age, mean (SD), range, weeks</td>
<td>36.7 (5.1), 24-41</td>
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<tr>
<td>Weight, mean (SD), range, kg</td>
<td>4.9 (1.8), 2.2-9.5</td>
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<tr>
<td>Number of feeding tube aspirates</td>
<td>54</td>
</tr>
<tr>
<td>Feeding tube site from which aspirates obtained</td>
<td></td>
</tr>
<tr>
<td>Gastric</td>
<td>50</td>
</tr>
<tr>
<td>Esophagus</td>
<td>2</td>
</tr>
<tr>
<td>Duodenum</td>
<td>2</td>
</tr>
<tr>
<td>Feeding status of infant at time of gastric aspirate collection</td>
<td></td>
</tr>
<tr>
<td>Not fed during previous 2 hours</td>
<td>42</td>
</tr>
<tr>
<td>Continuous feedingb</td>
<td>7</td>
</tr>
<tr>
<td>Bolus feeding within previous 2 hours</td>
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<tr>
<td>Type of feeding at time of gastric aspirate collection</td>
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<tr>
<td>Enteral formula</td>
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<tr>
<td>Breast milk</td>
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<tr>
<td>Unknown</td>
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</tr>
<tr>
<td>Use of gastric acid inhibitor</td>
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</tr>
<tr>
<td>No</td>
<td>32</td>
</tr>
<tr>
<td>Yes</td>
<td>18</td>
</tr>
<tr>
<td>H2-receptor antagonist</td>
<td>16</td>
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<tr>
<td>Proton pump inhibitor</td>
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<tr>
<td>Route of administration of gastric acid inhibitor</td>
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<tr>
<td>Enteral</td>
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<td>Unknown</td>
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<tr>
<td>Reason for admission, % of patients</td>
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<td>Congenital heart disease</td>
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<td>Respiratory failure</td>
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<td>Sepsis</td>
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<tr>
<td>Neurological problems</td>
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</tr>
<tr>
<td>Other</td>
<td>6</td>
</tr>
</tbody>
</table>

a Values are number of patients unless otherwise indicated in first column.
b Rate of administration, mean (SD) = 14.7 (5.5) mL/h.

Results
As indicated in Table 1, 50 of the 54 infants had feeding tubes situated in the stomach. The remaining 4 tubes were in nongastric sites: 2 in the esophagus and 2 in the proximal small bowel. These 2 positions were unexpected because all of the tubes
were intended for gastric placement. None of the tubes were positioned in the respiratory tract.

The 2 esophageal aspirates had pH values of 2.9 and 6.3, and the 2 duodenal aspirates had pH values of 4.9 and 6.0. Table 2 gives pH data for the 50 gastric aspirates.

In comparisons of the pH of the 13 gastric aspirates from infants in category 2 (use of a gastric acid inhibitor) with the pH of the 29 gastric aspirates from infants in category 1 (control group), the mean pH of the infants in category 2 (4.89; SD, 1.35) was significantly higher (t40 = -3.804; P = .002) than that of infants in category 1 (3.43; SD, 0.83). The results were similar when the data were analyzed by using the Mann-Whitney test (U = 70.5; P = .001). The effect size for this comparison is moderate to low (d = 0.56).

The number of gastric aspirates (n = 3) from infants in category 3 (a recent feeding) was too low to compare with the aspirates from infants in category 1. The pH values of the 3 gastric aspirates were 4.4, 5.4, and 6.0 (mean, 5.27; SD, 0.81); all 3 of these infants were continuously fed.

In comparisons of the 5 gastric aspirates from infants in category 4 (both use of a gastric acid inhibitor and a recent feeding) with the 29 gastric aspirates from infants in category 1 (control group), mean pH values were significantly higher (t32 = -3.804; P < .001) in the infants in category 4 (4.86; SD, 0.13) than in the infants in the control group (3.43; SD, 0.83). The sample size in category 4 was small (n = 5), but research has shown that the cut point yields adequate values with a low sample size. The results were similar when the data were analyzed by using the Mann-Whitney test (U = 13.5; P = .002). The effect size for this comparison was moderate (d = 0.77).

No significant correlation was found between age in weeks and gastric aspirate pH in the 29 infants in category 1 (r = -0.280; P = .15). An inadequate sample was available to determine the effect of specific gastric acid inhibitors on the gastric pH of the 13 infants in category 2 (11 infants received an H2-receptor antagonist and 2 received a proton pump inhibitor). Of the 5 infants in category 4, all received an H2-receptor antagonist.

Discussion

As expected, the 29 gastric aspirates from infants in category 1 (no gastric acid inhibitor and no recent feeding) had a significantly lower mean gastric pH than did the 21 aspirates from the infants who received a gastric acid inhibitor, a recent feeding, or both a gastric acid inhibitor and a recent feeding (categories 2, 3, and 4, respectively).

A high percentage of the gastric aspirates from infants in category 1 had pH values of 5.0 or less (93%) and 5.5 or less (97%). As shown in Table 2, the percentages of gastric aspirates with pH values of 5.0 or less and 5.5 or less were lower in infants in categories 2 and 3, indicating the pH-elevating capability of use of gastric acid inhibitors and recent feeding. Selection of a pH cut point of 5.5 or less is advocated by some authorities to indicate gastric placement. However, others have cautioned that a cut point of 5.0 or less is a safer value to rule out respiratory placement of feeding tubes. Of note, neither of these 2 cut points (≤5.0 and ≤5.5) could be used to rule out esophageal or small-bowel placement.

Neither cut point could be used to rule out esophageal or small-bowel placement.
Tracheal secretions typically have pH values of 6.0 or greater.

Strengths and Limitations

Our study has several strengths. First, the sample was limited to infants (a group thought to have gastric pH values higher than the values of older children and adults). Second, we addressed the effect of gastric acid inhibitors and recent feedings on the pH of aspirates from nasogastric tubes. Limitations are the small sample size and unequal distribution among the 4 categories. Because of the small sample size, we could not make meaningful comparisons according to important variables such as age, types and routes of gastric acid inhibitors, and feeding methods. Another limitation is the use of colorimetric pH tests instead of a pH meter to measure the pH.

Conclusions

Regardless of the use of gastric acid inhibitors and recent feedings, our findings tend to support the assumption by the National Health Service in the United Kingdom\(^2\) that gastric aspirates in children often have pH values of 5.5 or less. An important caveat is that a pH cut point of 5.5 or less cannot be used to rule out esophageal or duodenal placement of a feeding tube. Inability to identify esophageal placement increases risk for aspiration. Because the pH method is not 100% accurate, we recommend that radiography be used to confirm correct positioning of a newly inserted nasogastric tube whenever possible before initial use of the tube for feedings or administration of medications. When radiography is not possible, a reasonable conclusion is that a properly obtained and interpreted pH reading of 5.5 or less indicates that the feeding tube has not been positioned in the lung. As stated earlier, tracheal secretions typically have pH values of 6 or greater.\(^3,23\) Clearly, our study needs to be replicated with a much larger sample, and additional studies are needed to search for other reliable bedside methods for determining placement of feeding tubes.

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FINANCIAL DISCLOSURES

None reported.

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