



# 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)

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**R**adiography 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.<sup>1</sup> Testing the pH of feeding tube aspirates is frequently recommended<sup>2,3</sup> but infrequently used.<sup>4</sup> 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.<sup>5,6</sup> 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.<sup>7</sup> However, evidence<sup>8,9</sup> 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<sup>10</sup> 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.<sup>11</sup>

### Gastric Acid Inhibiting Agents

Although the aim of gastric acid inhibitors is to raise gastric pH to greater than 4, evidence<sup>3,12-14</sup> 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<sup>15</sup> 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<sup>10</sup> 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.<sup>16</sup> Thus, because infants receive frequent feedings, their gastric pH may be greater than 4 for prolonged periods.<sup>17</sup> Nonetheless, studies<sup>18,19</sup> 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.

**Radiography is the most accurate method to determine placement of nasogastric tubes.**

## 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,

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**Table 1**  
Summary of demographic and clinical data

Variable	Value <sup>a</sup>
No. of participants	54
Age, mean (SD), range, weeks	16.2 (14.9), 0.5-50
Gestational age, mean (SD), range, weeks	36.7 (5.1), 24-41
Weight, mean (SD), range, kg	4.9 (1.8), 2.2-9.5
Number of feeding tube aspirates	54
Feeding tube site from which aspirates obtained	
Gastric	50
Esophagus	2
Duodenum	2
Feeding status of infant at time of gastric aspirate collection	
Not fed during previous 2 hours	42
Continuous feeding <sup>b</sup>	7
Bolus feeding within previous 2 hours	1
Type of feeding at time of gastric aspirate collection	
Enteral formula	5
Breast milk	2
Unknown	1
Use of gastric acid inhibitor	
No	32
Yes	18
H <sub>2</sub> -receptor antagonist	16
Proton pump inhibitor	2
Route of administration of gastric acid inhibitor	
Intravenous	8
Enteral	8
Unknown	2
Reason for admission, % of patients	
Congenital heart disease	54
Respiratory failure	32
Sepsis	4
Neurological problems	4
Other	6

<sup>a</sup> Values are number of patients unless otherwise indicated in first column.

<sup>b</sup> Rate of administration, mean (SD) = 14.7 (5.5) mL/h.

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 a pH paper calibrated in increments of 0.3 units (Hydrion Microfine 2.9-5.2, Micro Essential Laboratory Inc). If the reading from the first test was greater than 5, 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.

## 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

**Table 2**  
Description of pH data for gastric aspirates from 50 infants according to use or no use of gastric acid inhibitors and recent feedings

Treatment category	Number of infants	Gastric aspirate pH		Percentage of gastric aspirates	
		Mean (SD)	Range	With pH ≤ 5.0	With pH ≤ 5.5
1, 2, 3, and 4 combined	50	4.06 (1.20)	2.9-6.9	76	90
1 (control group): no use of a gastric acid inhibitor and no recent feeding	29	3.43 (0.83)	2.9-6.0	93	97
2: use of a gastric acid inhibitor	13	4.89 (1.35)	2.9-6.9	46	77
3: a recent feeding	3	5.27 (0.81)	4.4-6.0	33	67
4: use of a gastric acid inhibitor and a recent feeding	5	4.86 (0.13)	4.8-5.1	80	100

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 ( $t_{40} = -4.304$ ;  $P = .002$ ) 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 ( $t_{32} = -3.804$ ;  $P < .001$ ) 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<sup>20</sup> has shown that the  $t$  test 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 H<sub>2</sub>-receptor antagonist and 2 received a proton pump inhibitor). Of

the 5 infants in category 4, all received an H<sub>2</sub>-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<sup>21</sup> to indicate gastric placement. However, others<sup>10</sup> 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 ( $\leq 5.0$  and  $\leq 5.5$ ) could be used to rule out esophageal or small-bowel placement. For example, 1 of the 2 esophageal aspirates had a low pH (2.9), most likely indicating reflux of gastric secretions into the esophagus. The second esophageal aspirate had a high pH (6.3), most likely indicating the presence of swallowed saliva. Almost identical findings have been reported in adults with esophageal tube placements.<sup>22</sup> And, as indicated earlier, 1 of the small-bowel aspirates had a pH value of 4.9; of note, a pH less than 6 is unlikely in the small bowel. For example, in a prospective study<sup>12</sup> of 56 acutely ill children (age, birth to 14 years), the mean pH of intestinal feeding tube aspirates (7.5; SD, 0.33; as measured with a pH meter)

Neither cut point could be used to rule out esophageal or small-bowel placement.

was significantly higher ( $P < .001$ ) than that of gastric aspirates (4.1; SD, 0.32).

Obviously, ensuring that the feeding tube has not entered the lung is critical during a blind tube insertion; measuring the pH of an aspirate from the tube may be helpful in this regard. For example, an aspirate with a pH of 5.5 or less most likely is an indicator of nonrespiratory placement because tracheal secretions typically have pH values of 6.0 or greater. In a study of the pH of 65 endotracheal aspirates collected from 19 critically ill children, Gilbertson et al<sup>10</sup> found a mean pH of 8.4 (range, 6.0-9.0). These values are similar to the mean pH of tracheal secretions collected from 20 acutely ill adults (mean, 7.8; range 6.2-8.8).<sup>23</sup>

In the United Kingdom, the pH method is recommended as the first line of defense to distinguish between respiratory and gastric tube placement in both adults and children; radiography is recommended only when the pH of an aspirate is greater than 5.5.<sup>21</sup> A best-evidence statement issued by the Cincinnati Children's Hospital Medical Center<sup>24</sup> rec-

ommends radiological verification for placement of nasogastric and orogastric tubes in infants and children who are at high risk for aspiration, when nonradiological methods are not feasible, or results are unclear. The statement also recommends that nonradiological verification methods be used to confirm placement of nasogastric and orogastric tubes in infants and children who are not considered at high risk for aspiration. When the pH of an aspirate is determined, a cut point of 5.0 or less is recommended for confirmation of gastric placement.<sup>24</sup>

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#### FINANCIAL DISCLOSURES

None reported.

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For more about feeding tube placement, visit the *Critical Care Nurse* website, [www.ccnonline.org](http://www.ccnonline.org), and read the article by Bourgault et al, "Methods Used by Critical Care Nurses to Verify Feeding Tube Placement in Clinical Practice" (February 2015).

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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

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