



Oral Feeding Reduces Hospitalizations Compared with Gastrostomy Feeding in Infants and Children Who Aspirate

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Objective To compare the frequency of hospitalization rates between patients with aspiration treated with gastrostomy vs those fed oral thickened liquids.

Study design A retrospective review was performed of patients with an abnormal videofluoroscopic swallow study between February 2006 and August 2013; 114 patients at Boston Children's Hospital were included. Frequency, length, and type of hospitalizations within 1 year of abnormal swallow study or gastrostomy tube (g-tube) placement were analyzed using a negative binomial regression model.

Results Patients fed by g-tube had a median of 2 (IQR 1, 3) admissions per year compared with patients fed orally who had a 1 (IQR 0, 1) admissions per year, $P < .0001$. Patients fed by gastrostomy were hospitalized for more days (median 24 [IQR 6, 53] days) vs patients fed orally (median 2 [IQR 1, 4] days, [$P < .001$]). Despite the potential risk of feeding patients orally, no differences in total pulmonary admissions (incidence rate ratio 1.65; 95% CI [0.70, 3.84]) between the 2 groups were found, except patients fed by g-tube had 2.58 times (95% CI [1.02, 6.49]) more urgent pulmonary admissions.

Conclusions Patients who underwent g-tube placement for the treatment of aspiration had 2 times as many admissions compared with patients with aspiration who were fed orally. We recommend a trial of oral feeding in all children cleared to take nectar or honey thickened liquids prior to g-tube placement. (*J Pediatr* 2016;170:79-84).

Aspiration during swallowing is a common diagnosis in infants and children with and without developmental delay.¹⁻⁷ Management approaches have included gastrostomy tube (g-tube) feeding, g-tube feeding with concurrent antireflux surgery (fundoplication), transpyloric feeding, and oral feeding with thickening of liquids. G-tubes are frequently used in order to allow for additional enteral access in patients with aspiration, including those thought to be at risk of having respiratory complications.⁸⁻¹¹ Prior data have suggested that for children with neurologic disability, g-tube placement may improve respiratory outcomes, including decreased antibiotic use and respiratory related hospitalizations.¹² Conversely, additional studies have shown that once placed, g-tubes are often fraught with complications, ranging from the minor (tube leakage, skin irritation, or formation of granulation tissue formation) to the more severe (worsening gastroesophageal reflux disease, g-tube cellulitis, or g-tube dislodgement).^{10,13-15} To date, there have been no studies comparing clinical outcomes in aspirating children treated with oral thickened liquids to those treated with g-tube placement.¹²

Since the development of aerodigestive centers in which patients are seen by gastroenterologists and pulmonologists together along with other subspecialties (eg, feeding therapy, otolaryngology), there has been a practice shift at many institutions away from g-tube placement and more toward continuing to feed children with aspiration orally with close combined gastroenterology, feeding team, and pulmonary follow-up. This shift has occurred in an effort to prevent feeding aversions and the complications surrounding g-tubes. Yet, there are no data comparing outcomes of these patients undergoing continued oral feeding vs g-tube placement. Before 2010, it was common practice at Boston Children's Hospital (BCH) to place g-tubes in patients who had aspiration confirmed by videofluoroscopic swallow study (VFSS). Prior data from our institution suggested that almost one-third of all patients undergoing primary percutaneous endoscopic g-tube placement had a preoperative diagnosis of aspiration.^{9,16} After 2010, many children with aspiration continued to be fed orally with thickened liquids rather than by g-tube.

The primary aim of this study was to compare the frequency of hospitalizations between patients with aspiration who were treated with g-tube placement vs those who were maintained on exclusive oral thickened feedings.

BCH	Boston Children's Hospital
g-tube	Gastrostomy tube
IRR	Incidence rate ratio
VFSS	Videofluoroscopic swallow study

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Methods

Institutional approval was granted to complete a retrospective chart review of patients with an abnormal VFSS at BCH between February 2006 and August 2013. Queries of hospital administrative data using Epic (v 2008; Epic Systems Corporation, Verona, Wisconsin) was performed to identify patients with a documented history of aspiration undergoing primary percutaneous endoscopic g-tube placement; additional reviews of an ambulatory BCH Aerodigestive Clinic administrative list were used to identify patients with documented aspiration treated with oral thickened feeds.

All included patients had evidence of documented aspiration or penetration of thin liquids and/or nectar thick liquids via a VFSS. Any patient who had an unknown level of aspiration or aspirated all textures (thin, nectar, honey-thick, or pureed foods) were excluded. Enrolled patients were then divided into 2 groups: (1) patients who underwent g-tube placement without any preoperative documentation of an oral thickening feeding trial (g-tube group); or (2) patients who were continued on exclusive oral feeding with thickening agents (oral group). Any patients fed orally who subsequently required g-tube feedings were excluded from the primary analysis but were reanalyzed as a part of the oral group as a secondary analysis. We excluded any patients fed by g-tube who went on to require post-pyloric feedings or fundoplication because in both of these cases, not only was oropharyngeal dysphagia treated but so was gastroesophageal reflux so clarifying the treatment effect of oropharyngeal dysphagia alone would not have been possible. All patients fed orally were treated with standardized thickening recipes using either infant cereal or xanthan gum.

Our primary outcome was defined as the total number of hospitalizations within 1 year of g-tube placement (for the g-tube fed group) or within 1 year of the first abnormal VFSS (for the oral group). Secondary outcomes included total number of inpatient days, frequency of subsequent pulmonary, gastroenterology, or other types of admissions, as well as whether or not the hospitalization was elective or urgent within 1 year of their index event (either the placement of a g-tube or first abnormal VFSS). Urgent admissions were defined as any unplanned admission or admissions admitted through the emergency department. We also examined the number of patients who underwent a repeat VFSS within 1 year of their initial study (for oral group), or within 1 year of g-tube placement (for the g-tube group), as well as the frequency of normal repeat VFSS results. We also reviewed the patient characteristics of a subset of excluded patients fed orally who went on to require g-tube feedings.

Patient records were reviewed for sex, age, and weight at the time of their first abnormal VFSS. Patient comorbidities were categorized as being neurologic, cardiac, gastrointestinal, pulmonary, oropharyngeal, renal, metabolic/genetic, immunologic, or having a history of premature birth (<37 weeks gestation). Comorbidities were not considered

to be mutually exclusive. Extent and type of aspiration on VFSS were also recorded for all patients.

Patient characteristics for the g-tube group were compared with the oral group using both parametric and nonparametric methods as appropriate. Pearson χ^2 test was used for cross-tabulations unless any expected cell-count was <5, in which case Fisher exact test was used. Student *t* test was used for continuous variables when normally distributed and the Wilcoxon rank-sum test otherwise.

A generalized linear model was used to adjust for subject characteristics, including neurologic, cardiac, and pulmonary comorbidities, as well as sex, age, and weight-for-age z-score. The primary and secondary outcomes, including number of hospitalization admissions as well as inpatient days among those hospitalized, were highly right-skewed, and the data were over dispersed. Therefore, a negative binomial regression provided a better fit than a Poisson regression model, based on visual inspection of the regression curve overlaid on a plot of the mean predicted probability against the observed counts and the Akaike information criterion.^{17,18} Outcomes were modeled using SAS v 9.3 (SAS Institute, Cary, North Carolina). Results were expressed on a multiplicative scale as the ratio of mean outcome in the g-tube group to mean outcome in the oral group (incidence rate ratio [IRR]) with a 95% CI.¹⁹ An additional propensity score regression analysis was performed to include a propensity score to adjust for differences in the 2 populations. All statistical tests were 2-sided with a *P* value of <.05 considered statistically significant.

Results

A total of 114 patients were included in the analysis, 49 patients who were exclusively fed oral thickened feeds (oral group) and 65 patients who received a g-tube (g-tube group). Differences in subject characteristics at the time of study entry are shown in [Table I](#). Patients did not differ statistically by sex, ethnicity, race, or prematurity status at the time of their first abnormal VFSS, but subjects in the g-tube group were lower in weight (*P* = .0003) and age (*P* = .003) than those in the oral group. There was no difference in the prevalence of gastrointestinal comorbidities, but patients fed by g-tube were more likely to have cardiac, neurologic, metabolic, and renal comorbidities, and patients fed orally were more likely to have pulmonary and otolaryngology comorbidities.

Aspiration of thin liquids alone was more prevalent among patients fed orally fed vs patients fed by g-tubes (36 [73%] vs 25 [38%], respectively; *P* < .001) on the initial VFSS. Eighty (71%) patients, 32 fed orally and 49 fed by g-tubes, underwent a repeat VFSS within a year. Of those patients who underwent repeat swallow studies, 6/32 (19%) patients fed orally vs 21/49 (43%) patients fed by g-tubes, had a subsequent normal VFSS (*P* = .02).

Unadjusted results for total hospitalizations and inpatient days within 1 year of the first abnormal VFSS for the oral fed vs g-tube fed groups are shown in [Table II](#). Median (IQR)

Table I. Comparison of patient characteristics taken at the time of first abnormal swallow study for patients treated with oral thickening vs g-tube tube feedings (n = 114)

	Orally fed (n = 49)	G-tube fed (n = 65)	P*
Characteristics			
Female sex	17 (35%)	32 (49%)	.12
Hispanic (unknown for n = 29)	5 (13%)	7 (16%)	.69
White	37 (76%)	41 (63%)	.16
Prematurity	21 (43%)	24 (37%)	.52
Age, median (IQR), mo	14.2 (8.2, 19.8)	4.8 (2.0, 15.6)	.003
Weight, median (IQR), kg	10.4 (8.4, 12.2)	6.4 (4.2, 9.3)	.0003
Weight-for-age z-score	-0.11 ± 1.81	-1.31 ± 2.63	.005
Comorbidities			
Gastrointestinal	48 (98%)	60 (92%)	.23
Cardiac	6 (12%)	25 (38%)	.002
Neurologic	20 (41%)	54 (83%)	<.0001
Pulmonary	42 (86%)	40 (62%)	.005
Otolaryngology	43 (88%)	15 (23%)	<.0001
Metabolic	8 (16%)	26 (40%)	.006
Renal	0 (0%)	11 (17%)	.002
Immunologic	3 (6%)	1 (2%)	.31

*P values calculated from χ^2 , Fisher exact, Wilcoxon rank-sum test, or Student *t* test where appropriate.

total number of admissions was lower among the oral group than with the g-tube group (1 [0, 1] vs 2 [1, 3]; $P < .0001$), as was the total number of inpatient days (2 [1, 4] vs 24 [6, 53]; $P < .0001$). Patients in the oral group also had a lower prevalence of gastroenterology and intensive care unit admissions than g-tube fed patients ($P < .001$) and similar rates of pulmonary admissions ($P = .69$).

Among the 94 patients ever admitted, there was no statistical difference between the 2 groups in the prevalence of urgent admissions overall ($P = .48$; data not shown); however, among the 35 patients admitted for pulmonary care, 69% of the oral group were admitted urgently compared with 100% of g-tube group ($P = .01$), even though these 35 patients were balanced with respect to pulmonary comorbidities (94% vs 95%, respectively; $P = 1.0$).

The distribution of total admissions for the patients fed orally and patients fed by g-tube is shown in **Figure 1**. For

Table II. Comparison of hospitalizations within 1 year of first abnormal swallow study (oral group) or within 1 year of g-tube placement (g-tube group; n = 114)

	Oral group (n = 49)	G-tube group (n = 65)	P*
Total number of admissions, median (IQR)	1 (0, 1)	2 (1, 3)	<.0001
Total number of inpatient d, median (IQR)	2, (1, 4)	24 (6, 52.5)	<.0001
Type of hospitalization, n (%)			
Gastrointestinal admission	10 (20%)	41 (63%)	<.0001
Pulmonary admission	16 (33%)	19 (29%)	.69
Intensive care unit admission	1 (2%)	18 (28%)	.0003
Other admission [†]	13 (27%)	28/65 (43%)	.07

*P value from χ^2 or Wilcoxon rank-sum test.

[†]Other included admissions: general surgery or other specialty surgical services (urology, or thopedics, and otolaryngology), general pediatric services, or other subspecialty medical services (nephrology, genetics/metabolism, coordinated care service, cardiology, or neurology).

the urgent gastrointestinal admissions, in the g-tube group, 56% of admissions were for g-tube-related problems, 23% were for poor growth, 12% were for vomiting, and 8% were for gastrointestinal infections. In the oral group, 83% had gastrointestinal infections and 17% had feeding difficulties.

The results of negative binomial regression, used to investigate the independent effect of g-tube vs oral feeding on total and urgent admission rates, after adjusting for neurologic, cardiac, and pulmonary comorbidities, as well as sex, age, and weight, are shown in **Figure 2**. Patients treated with a g-tube had on average 2.15 (95% CI [1.45, 3.20]) times more total admissions, and among those admitted, 7.46 (95% CI [4.28, 13.0]) times more inpatient days than patients fed orally. On average, the g-tube group also had 2.96 (95% CI [1.43, 6.11]) times more gastroenterology admissions than the oral group; on review, these were likely due to more g-tube-related admissions in the g-tube-treated group. There were no differences in total pulmonary admissions IRR 1.65 (95% CI [0.70, 3.84]) or respiratory events between the 2 groups, but patient fed by g-tube had 2.58 times (95% CI [1.02, 6.49]) more urgent pulmonary admissions than the patients fed orally. Of note, the proportion of patients with admissions for reasons other than gastroenterology or pulmonary were <10% in the either the g-tube group or oral group and, therefore, was not modeled.

In addition, to try to reduce bias, we created a regression model adjusting for propensity score and g-tube status. Using this model, there were no differences in the directionality of the primary outcomes of total hospitalizations (IRR 2.42 [1.46, 4.00]) and total hospitalization days (IRR 11.37 [5.76, 22.46]) compared with the regression model.

Of the initial patients screened for inclusion in the oral group, an additional 11 patients failed thickening and went on to g-tube placement. To determine predictors of oral feeding failure, we compared the comorbidities of patients who were successful in oral trials compared with those who went on to g-tube placement. Patients who failed thickening trials had a higher rate of neurologic comorbidities (94% vs 42% respectively, $P < .001$) and cardiac comorbidities (44% vs 12%, $P = .007$). We also then included these “oral failure” patients in the total analysis in the oral group to reduce the chance that excluding these patients would create bias. When we re-did the primary negative binomial regression model with these 11 patients included, there was no difference in any of the outcomes regarding significance but the IRR effect was attenuated. For the primary outcomes of total hospitalizations and total hospitalization days, the IRR comparing patients fed by g-tube with patients fed orally (with the 11 “oral failures” included) were 1.75 (1.28, 2.41) and 4.52 (2.92, 6.99), respectively. Even when the “oral failure” patients were included, there were still significantly more hospitalizations and hospitalization days in the patients fed by g-tube.

To address whether the severity of aspiration affected hospitalization, we grouped patients into those that just

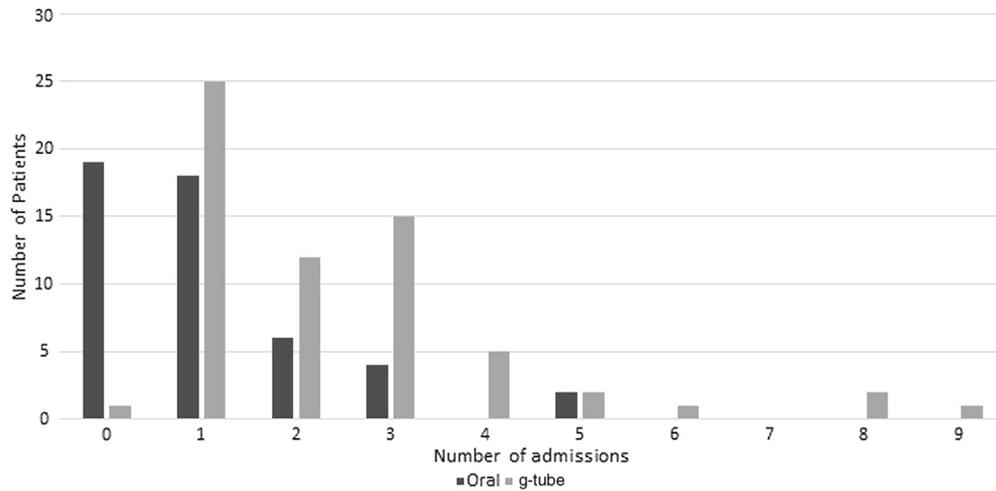


Figure 1. Distribution of admissions in patients fed orally and in patients with g-tubes.

aspirated thin liquids (n = 61) and those that aspirated thin and nectar thick liquids (n = 53). There was no difference in the total admissions in the thin (1.0 [1.0, 2.0]) and thin and nectar (2.0 [1.0, 3.0], *P* = .7) or in the total hospitalization days between those that aspirate thin liquids (4.0 [2.0, 40.0]) and those that aspirate thin and nectar (18.5 [3.5, 36.6], *P* = .08). After adjusting for g-tube status, there were no differences in the comorbidities of those that

aspirate thin vs thin and nectar except prematurity (*P* = .002).

We also divided patients into those that had aspiration on their swallow study (n = 103) and compared their rates of hospitalization with those that just had penetration (n = 11) and found no difference in hospitalization rates or days between the 2 groups (*P* > .5) but the sample size in the penetration group was small.

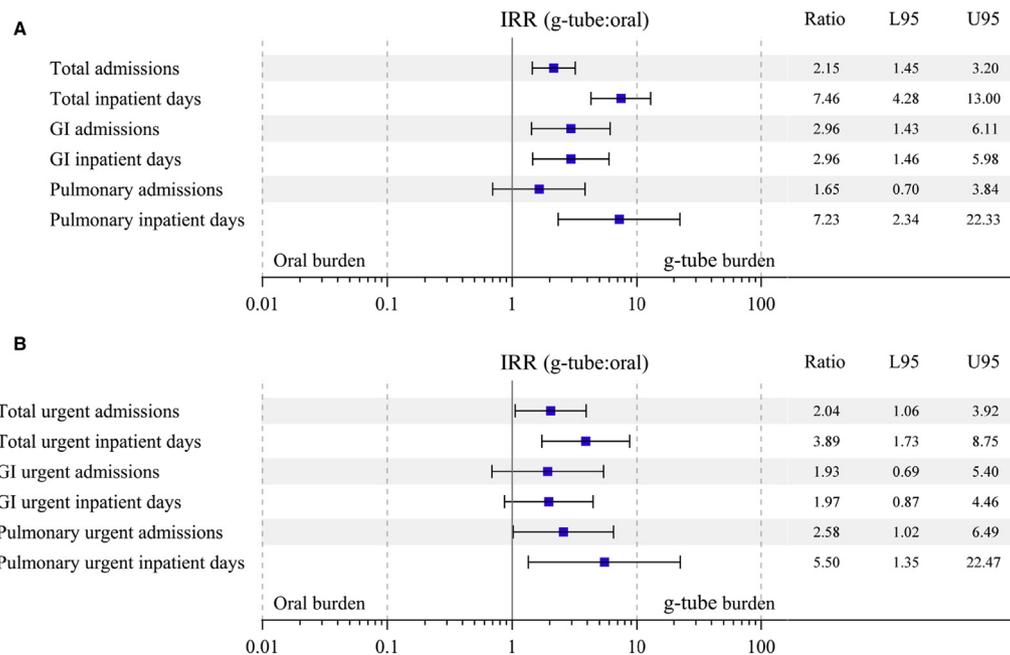


Figure 2. Forest plots showing results of negative binomial regression, adjusted for neurologic, cardiac, and pulmonary comorbidities, as well as sex, age, and weight-for-age z-score. **A**, Total admissions and inpatient days among those admitted, as well as type of admissions. **B**, Total urgent admissions and inpatient days among those with urgent admissions, as well as types of urgent admissions. Results are expressed on a multiplicative scale, as the ratio of the incidence rate in the g-tube group to the incidence rate in the oral group. Analysis of inpatient days were restricted to admitted patients only. *GI*, gastrointestinal.

Discussion

Placement of a g-tube has historically been one of the primary methods for treatment for children with aspiration.^{8,9,11} There has been an increasing trend to continue to feed children by mouth in an effort to avoid the morbidity of g-tubes, which often includes not only potential mechanical complications from the tube itself (eg, skin infections, tube dislodgement) but potential worsening of gastroesophageal reflux or development of prolonged oral aversions preventing patients from weaning off their g-tube feeds.^{8,9,20-23}

The primary aim of this study was to determine if a modified oral feeding regimen with thickeners in children with aspiration resulted in an increased risk of hospitalizations when compared with patients fed by g-tube. We found that children fed orally were not admitted with any greater frequency than children who were g-tube dependent. In fact, children fed by g-tube had on average twice the number of hospitalizations compared with those who were fed orally. In addition, there were no differences in the frequency of total pulmonary admissions between patients fed orally and patients fed by g-tube suggesting that when you thicken oral feeds, you eliminate the risk of pneumonia, which has been reported in children who aspirate thin liquids.⁶

One explanation for why the presence of a g-tube may worsen outcomes in children with aspiration is that g-tubes in certain children may increase the presence of gastroesophageal reflux, which may result in an increased risk of adverse pulmonary outcomes. Several studies have addressed this issue. In 1 study, patients with feeding difficulties underwent either a g-tube placement or a combined g-tube placement with prophylactic fundoplication to prevent reflux-related complications.² The authors found that the addition of an antireflux procedure to g-tube placement did not change the risk of respiratory complications, suggesting that aspiration of refluxed gastric contents did not contribute significantly to hospitalization risk. A similar study reviewing infants with bronchopulmonary dysplasia, who received either a g-tube or a g-tube with Nissen fundoplication, found that pulmonary outcomes did not improve in either group over infants who were orally fed, again suggesting gastroesophageal reflux was not a significant issue in pulmonary morbidity. In fact, infants who underwent fundoplication had a significantly higher rate of rehospitalization.²⁴ In both of these studies, the swallow function of the patients was not assessed. To address the impact of reflux and swallowing function, we studied hospitalization rates in 116 children who had gastroesophageal reflux testing by multichannel intraluminal impedance with pH testing and VFSS. We found that, even after adjusting for aspiration status, reflux burden did not predict the number of hospitalizations or the days hospitalized, suggesting that even in aspirating patients, reflux is not a significant contributor to hospitalizations.²⁵

Another potential possibility for the differences in hospitalization rates is higher g-tube-related admissions. Gastroin-

testinal causes for admission dominated and the most common reasons for the admission in the g-tube group were lengthy admissions at the time of tube placement, cellulitis, feeding intolerance, vomiting, and poor weight gain.

One limitation to our study is that children fed by g-tube had more comorbidities that may have affected the decision to undergo g-tube placement, thereby biasing the results. Ideally, we would also have compared admissions prior to and after g-tube/oral thickening initiation but because of the young age of the patients included in the study, there was a very short “preintervention” time period to assess admissions. However, to try to address any possible bias, we have performed both a binomial regression model and propensity score analyses and both models gave identical results. Our results are in contrast to a single prior pediatric study, which found a significant reduction in the frequency of antibiotic use and respiratory admissions in patients with cerebral palsy treated with g-tubes, including patients known to aspirate based on abnormal videofluoroscopy.¹² In addition, there was no orally fed control group in this study, which may have also helped to better decipher if the g-tube itself also impacted admission rates. However, our findings that children fed orally have equivalent or fewer hospitalizations than patients fed by g-tube are also similar to adult studies of patients with multiple comorbidities and who are at risk for impaired swallowing. Prior adult data have shown that both survival and aspiration pneumonia were either the same or better in patients fed orally compared with patients receiving enteral feeds.²⁶⁻²⁹ Our results support a role for a trial of oral thickening before g-tube placement in any child whose swallow study shows that they are able to take either nectar or honey thickened liquids.

Of note, over one-half of the patients who underwent g-tube placement and repeat VFSS within 1 year of their surgery had improvement in their swallow function, and these rates of aspiration resolution were actually higher in the g-tube group than in the oral group. We hypothesize this finding represents the fact that, prior to the creation of aerodigestive centers, many patients with neonatal swallowing dysfunction underwent g-tube placement, and this high rate of VFSS improvement represents a large proportion of very young patients with neonatal swallowing dysfunction in whom swallow function improves over time. Clearly, the fact that many children experience improvement in swallow function over time should be factored into the decision on whether to place a g-tube.

We have shown that oral thickened feeding is safe and well tolerated in the majority of patients with aspiration. None of our patients receiving thickening were admitted for dehydration, and recent data supports the finding that thickening does not have any impact on dehydration risk as evidenced by water absorption studies.^{30,31} We do recognize that some patients will not be able to maintain calories, hydration status, and lung health with thickened oral feeding, and we had 11 patients who failed oral thickening trials and ultimately needed g-tube placement. The risk factors for oral failure were concurrent cardiac and neurologic comorbidities.

However, it is also important to note that some patients with neurologic symptoms and cardiac comorbidities were successful in oral feeding. Data from a study of patients with hypoplastic left heart undergoing interstage repair found that exclusive oral feeding resulted in improved weight gain vs infants who were treated with g-tube feedings.³² Therefore, more prospective studies are needed in order to better decipher which patients will go on to successful oral feeding trials vs those who will ultimately benefit from earlier g-tube placement.

Oral thickened feeding of children who aspirate thin or nectar liquids is a safe alternative to g-tube placement. Children with aspiration who were fed orally have a decreased risk of hospitalization in comparison with children fed by g-tube. We recommend a trial of oral feeding in children cleared to take thickened liquids, prior to g-tube placement, particularly in children with less comorbidity, significant underlying neurologic, or other disability, or in those whose swallowing function is likely to improve over time. ■

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