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Gastrostomy Tube Feeding in Extremely Low Birthweight Infants: Frequency, Associated Comorbidities, and Long-term Outcomes

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Abstract

Objective: To assess the frequency of gastrostomy tube (GT) placement in extremely low birth weight (ELBW) infants, associated co-morbidities, and long-term outcomes.

Study design: Analysis of ELBW infants from 25 centers enrolled in the National Institute of Child Health and Human Development Neonatal Research Network's Generic Database and Follow-up Registry from 2006-2012. Frequency of GT placement before 18-22 months, demographic and medical factors associated with GT placement, and associated long-term

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Data Sharing

Data reported in this paper may be requested through a data use agreement. Further details are available at https://neonatal.rti.org/index.cfm?fuseaction=DataRequest.Home.

outcomes at 18-22 months corrected age were described. Associations between GT placement and neonatal morbidities and long-term outcomes were assessed with logistic regression after adjustment for center and common covariables.

Results: Of the 4549 ELBW infants included in these analyses, 333 (7.3%) underwent GT placement; 76% had the GT placed post-discharge. Of infants with GTs, 11% had birth weights small for gestational age (SGA), 77% had bronchopulmonary dysplasia (BPD), and 29% severe intraventricular hemorrhage (IVH) or periventricular leukomalacia (PVL). At follow-up, 56% of infants with a GT had weight <10th percentile, 61% had neurodevelopmental impairment (NDI), and 55% had chronic breathing problems. After adjustment, SGA, BPD, IVH/PVL, poor growth and NDI were associated with GT placement. Thirty-two percent of infants with GTs placed were taking full oral feeds at follow-up.

Conclusions: GT placement is common in ELBW infants, particularly among those with severe neonatal morbidities. GT placement in this population was associated with poor growth, NDI and chronic respiratory and feeding problems at follow-up. The frequency of GT placement post-neonatal discharge indicates the need for close nutritional follow-up of ELBW infants.

Trial registration—ClinicalTrials.gov:

Oral feeding difficulties are common among extremely low birth weight (ELBW) infants. Coordination of suck-swallow-breathe patterns are critical to feeding success, but these skills typically evolve and mature starting at 33-34 weeks of gestation.[1-4] This process can be delayed in those who require invasive medical interventions (endotracheal intubation and long-term nasogastric (NG) feedings).[5,6] ELBW infants with poor oral feeding skills have prolonged hospital stays, incur increased health care costs and may be at increased risk for long-term deficits in feeding skills and neurodevelopment.[7,8]

ELBW infants with bronchopulmonary dysplasia (BPD) or severe neurologic injury are especially prone to ongoing feeding difficulties.[9,10] Infants with severe BPD have been found to have poorer coordination when feeding, poor endurance, and an inability to generate sucking pressures strong enough for successful oral feeding.[11,12] At follow-up visits, lower scores on neurodevelopmental testing in the cognitive and language domains have been demonstrated in ELBW infants with dysfunctional feeding behaviors.[13]

Oral feeding difficulties often necessitate alternative feeding options before or after NICU discharge. There is some evidence in the literature supporting early discharge with home gavage feeding in stable premature infants who have difficulties establishing full oral feeds.[14-16] Nonetheless, the overall frequency of GT placement in neonates has increased with one study showing the rate of GTs doubling in very low birthweight infants between 2000 and 2012.[17]

Although GT feeding in premature infants has been described in the literature, the frequency of use in ELBW infants and its association with other neonatal morbidities is unknown. The purpose of this study was to examine the frequency of GT placement in ELBW infants, to investigate the association with certain neonatal morbidities, and to evaluate longer-term growth and developmental outcomes.

Methods:

We performed a retrospective cohort analysis of all ELBW infants (birth weight <1,000 g) who were enrolled in the National Institute of Child Health and Human Development (NICHD) Neonatal Research Network's (NRN) Generic Database (clinicaltrials.gov:) between January 1, 2006 and December 31, 2012. Prior to discharge, all surgical procedures were noted. If an infant did not have a GT placed before discharge, then GT placement after discharge was determined by a question asked of the caregiver at follow-up. This was a simple yes or no question regarding whether the child had a gastrostomy tube or button placed. The timing of the follow-up evaluation changed during the research study period. Follow-up was performed between 18-22 months corrected age prior to 7/1/2012 and between 22-26 months corrected age afterwards. Infants were excluded from the analysis if they had significant congenital heart disease, an upper airway or GI malformation, or a syndrome or chromosomal abnormality. Infants who developed short bowel syndrome during their NICU stay necessitating a GT were excluded as these infants often require GT management for reasons other than oral feeding difficulties. Infants dying before or after NICU discharge, those not completing the developmental follow-up visit, and those with missing outcome data at discharge and at follow-up also were excluded (Figure; available at www.jpeds.com). Trained research personnel collected clinical data in a standardized manner.

Prevalence of GT placement prior to the follow-up visit, demographic and medical factors associated with GT placement, and associated outcomes (including: respiratory, feeding, growth, and neurodevelopmental outcomes) were documented. Demographic factors included race, sex, and maternal education level. Medical factors included in the analyses were a birth weight small for gestational age (SGA), bronchopulmonary dysplasia (BPD), severe intraventricular hemorrhage (IVH), periventricular leukomalacia (PVL), and necrotizing enterocolitis (NEC). SGA was defined as a birth weight <10th percentile for gestational age.[18] BPD was defined using the physiologic definition of infants at 36 weeks postmenstrual age.[19] IVH included grade III or IV.[20] NEC was defined as Stage IIA or greater on modified Bell's Staging criteria.[21,22] Infants diagnosed with surgical NEC leading to short bowel syndrome were excluded and not included in the primary analysis, however, information was gathered regarding the prevalence of GTs in this population. Longer-term outcomes evaluated were poor growth, neurodevelopmental impairment, "chronic feeding problems" (use of thickened feeds, abnormal swallowing, dysphagia, or documented aspiration at follow-up), and "chronic breathing problems" (use of oxygen, diuretics, or bronchodilators at follow-up). Poor growth, measured at follow-up on the National Center for Health Statistics (NCHS) growth curve, was defined as weight, length or head circumference <10th percentile for corrected age.[23] Infants were evaluated between 18-26 months adjusted age using the Bayley Scales of Infant and Toddler Development (BSID-III) and a standardized neurosensory examination. Neurodevelopmental impairment (NDI) was defined as any of the following: a cognitive composite score on the BSID III <85, moderate-to-severe cerebral palsy (CP), gross motor function classification system (GMFCS) level ≥2, severe hearing impairment, or bilateral severe visual impairment.[13]

Descriptive statistics were calculated for baseline characteristics, medical factors, and outcomes at follow-up. Frequencies and percentages were reported for categorical variables with differences in characteristics between groups tested for by chi-square tests or the Fisher exact test. Means, standard deviations, medians, and interquartile ranges were reported for continuous variables with differences tested using the Wilcoxon test. Logistic regression models were used to assess associations between GT placement and neonatal morbidities and outcomes at followup. Models included one characteristic at a time as the primary independent variable with center, gestational age, SGA, BPD, NEC, and severe IVH/PVL as covariables. Odds ratios were estimated with statistical significance determined by Wald chi-square tests. All analyses were conducted in SAS version 9.4.

Data were also gathered for infants discharged on nasogastric or nasojejunal (NG/NJ) feedings. This information, however, was limited and only available from 2008-2011. The characteristics of infants discharged on NG/NJ versus GT tubes were obtained as well as the prevalence of those who were initially discharged with NG/NJ feeds but received a GT prior to follow-up.

Results:

A total of 4549 ELBW infants from 25 centers met the inclusion criteria for the study and were included in the analyses. Of these, 333 (7.3%) of the infants underwent GT placement. Among those with a GT, 77% had BPD (253/333), 29% (96/333) had a grade III or IV IVH or PVL, and 7% (22/333) had NEC (Table 1). Variables that were found to be significantly associated with GT placement were birth weight SGA, BPD, and IVH or PVL, and length of hospital stay after adjustment for center and neonatal morbidities. Demographic factors such as sex, race, and maternal education level were not significantly associated with GT placement. A diagnosis of NEC was not associated with GT placement in our cohort (Table 2). For the 187 infants with surgical NEC, GT placement was significantly more likely in infants with short bowel syndrome (45%, 22/49) than in those without short bowel syndrome (9%, 12/138; $p<0.01$).

Most longer-term adverse outcomes were significantly more likely to occur in infants with GTs than in infants without GTs (Table 1). At follow-up, GT placement was associated with poorer growth, NDI, cerebral palsy, and chronic breathing and feeding problems.

Thirty-two percent (108/333) of the infants with a GT were taking full oral feeds at follow-up. Hispanic ethnicity, as well as all components of NDI, and breathing status at follow-up were independently associated with the ability to attain full oral feedings by 2 years. No specific neonatal morbidities were associated with a resolved need for GT supplementation at follow-up (Table 3).

Seventy-six percent (252/333) of those who underwent GT placement did so after discharge from the NICU. Significant differences between patients who had GT placed before and after discharge were slower growth of head circumference and increased chronic breathing and feeding problems among infants who underwent GT placement after discharge. There

was no significant difference in weight gain velocity after discharge between these two groups (Table 4).

Of the 2271 ELBW infants discharged between 2008-2011, 4% (93/2271) were discharged with NG or NJ feeds and 13/93 (14%) of these went on to receive GTs. Infants discharged on NG feeds were more likely to subsequently have a GT placed if they had a severe IVH or poor length and head growth at follow-up and less likely to have a GT placed if male. (Table 5; available at www.jpeds.com).

A fundoplication procedure was performed simultaneously with GT placement in 26% of the infants. There was wide center variation for GT placement and fundoplication rates. The rate of GT placement varied from 3-14% by center and fundoplication rates ranged from 0-6.4% among the centers (Table 6; available at www.jpeds.com).

Discussion:

GT placement is common among ELBW infants, especially among those with co-existing morbidities. The NICHD NRN collected information in their Generic Database from 2006-2012 on major surgeries, including GT placement before and after NICU discharge. The database provides a unique opportunity to assess the frequency of use of supplemental GT feeding in extremely preterm infants from multiple academic tertiary centers and to examine associations between this feeding strategy and long-term growth, respiratory, feeding and developmental outcomes in extremely premature infants.

In our cohort, the majority of infants had their GTs placed after discharge (76%) suggesting that a large proportion of ELBW infants were first discharged from the NICU orally feeding but could not maintain these skills. Although there was no significant difference in weight gain velocity between the two groups, ELBW infants were more likely to have a GT placed after discharge if they had chronic respiratory or feeding problems. The high percentage of GT placement post-neonatal discharge indicates a need for close nutritional follow-up of ELBW infants, especially those needing respiratory support such as supplemental oxygen, bronchodilator or diuretic therapy, as well as those with a history of dysphagia or who have risks for aspiration. In addition, oral feeding rehabilitation strategies prior to and following GT placement may be relevant in achieving better overall outcomes, both short-and long-term. Physiological basis for safe oral feeding practices that include volume tolerance and airway safety are both fundamental to successful oral feeding and prevention of need for a GT.[1,24] Further work is needed with standardization of oral feeding practices both in the NICU and post-discharge.

GT placement was most strongly associated with BPD followed by severe brain imaging abnormalities (IVH or PVL), then SGA. This is consistent with previous literature documenting the associations of severe BPD and feeding difficulties.[9,11,12] The association of significant neonatal brain injury and poor feeding skills is also not unexpected given the oromotor coordination and skills necessary to develop successful oral feeding abilities.

Longer-term outcomes associated with GT placement were assessed at follow-up. At two years of age, GT placement was associated with poor growth, NDI and chronic respiratory

and feeding problems. Although the reasons for failure to successfully transition to full oral feeds is poorly described in the literature, ongoing feeding difficulties recently have been described in ELBW infants from a 2006-2008 cohort, with 13% having dysfunctional feeding behaviors at 18-22 months corrected age. These feeding problems were defined as tube feedings, choking or coughing with oral feeds, a history of aspiration or difficulty swallowing.[13] Preterm infants are also nearly twice as likely to have oromotor dysfunction and avoidant feeding behaviors at 3 and 12 months corrected age.[3] Rommel described 700 infants and young children referred for evaluation and treatment of a severe feeding disorder and reported an overrepresentation of premature infants, especially those born at <34 weeks of gestation or with lower birth weights for gestational age.[25]

Early feeding problems in premature infants may have significant consequences for growth and development. Overall, children with feeding problems are at risk for nutritional deficiencies and poor growth, regardless GT placement, as well as poorer cognitive, motor, and language outcomes than children without feeding problems. Mizuno and Ueda demonstrated an association between neonatal feeding difficulties and developmental problems at 18-month follow up. In this study, the sensitivity and specificity of early feeding assessments were better predictors of neurodevelopmental outcomes than cranial ultrasound findings.[26] Adams-Chapman et al showed an association between feeding difficulties and language delays in ELBW infants at 18-22 month follow-up.[13] Behavioral and emotional problems have also been described in children with feeding problems.[27,28] Parents often struggle to cope with feeding difficulties in premature infants, and feeding issues may be a primary concern for families after discharge.[29,30] Because of this, an increasing number of premature infants are referred for feeding therapy for both infant skill development and parent support, often continuing through school age.[31]

Given the risk of complications associated with surgically placing a gastrostomy tube in an ELBW infant, as well as possibly increasing length of stay, a better understanding of the duration of “oral feeding failure” in an ELBW infant at NICU discharge will guide providers in making recommendations for discharge feeding plans.[32] There is evidence suggesting that supplemental home nasogastric tube feeding may be a safe and effective means for treating oral feeding problems in premature infants, yet many centers do not consider this practice for discharge.[14,15] In a Cochrane review comparing early discharge home with gavage feeds and health care support with later discharge home when full oral feeds have been established, it was concluded there were not enough quality trials to make a practice recommendation.[16] However, several small studies suggest not only a reduced length of stay, but also a reduction in infection and improved breastfeeding in the home gavage group.[15] Although our database did not capture information regarding home NG feeding at NICU discharge in its entirety, the available data showed that 14% of these patients eventually received a GT. This study may provide preliminary evidence to support a clinical trial of home NG vs GT feeding in otherwise stable premature infants with oral feeding problems, which could then identify optimal discharge feeding plans for ELBW infants.

Although our study provided new information about ELBW infants who undergo GT placement, there were several limitations. Primarily, were unable to determine the best method of feeding ELBW patients at discharge: prolonged hospitalization awaiting full oral

feeding, NG tube or GT. Optimistically, many babies discharged home with NG supplementation did not require GT placement, but we could not ascertain if complications occurred at home, if these children were readmitted to the hospital or the time interval between discharge and GT placement. We had limited information on the infants discharged with NG feeds who did not progress to GT placement. The study was also limited by the changing criteria for age of followup during the study period (from 18-22 to 22-26 months adjusted age). Lastly, the method of ascertainment for GT placement after discharge depended on caregiver recall, which allows for potential bias, and it was not validated with post-discharge hospital records.

The high percentage of GT placement we observed post-neonatal discharge indicates the need for close nutritional follow-up of ELBW infants. Further studies of nutritional interventions, including standardization of oral infant feeding guidelines, requirements for and timing of GT placement, as well as safety and efficacy of home GT versus NG supplementation are needed to identify optimal discharge feeding plans for ELBW infants.

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Appendix

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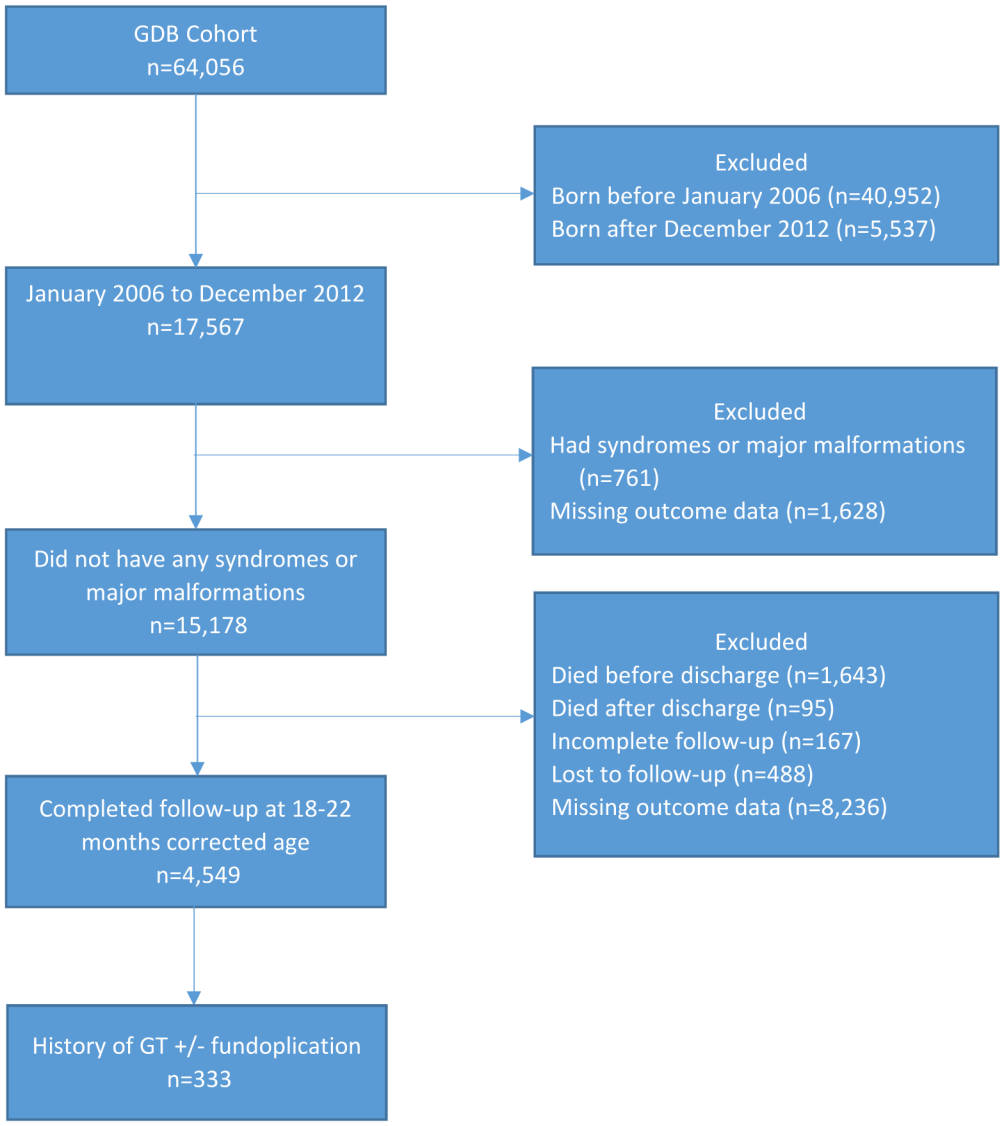

Figure 1. Patient Cohort

GDB database: January 2006 to December 2012 n=17,567

Excluded

Had syndromes or major malformations (n=761)

Died before discharge (n=1,643)

Died after discharge (n=95)

Incomplete follow-up (n=167)

Lost to follow-up (n=488)

Missing/empty outcome data (n=9,864)

Completed follow-up at 18-22 months corrected age (n=4,549)

Table 1.

Characteristics of patients with and without gastrostomy tube placement[1]

Variables	Total N=4549	No GT N=4216	GT N=333	P-value
Baseline characteristics				
Gestational Age, mean (SD)	25.73 (1.30)	25.76 (1.30)	25.43 (1.30)	<0.01
Small for Gestational Age, n (%)	315 (7)	277 (7)	38 (11)	<0.01
Male, n (%)	2245 (49)	2083 (49)	162 (49)	0.86
White, n (%)	2390 (53)	2203 (53)	187 (58)	0.13
Hispanic, n (%)	751 (17)	700 (17)	51 (16)	0.54
High School degree, n (%)	2601 (76)	2417 (76)	184 (74)	0.49
Neonatal characteristics				
Length of hospital stay (days), mean (SD)	112 (46)	108 (40)	169 (72)	<0.01
NEC, n (%)	250 (5)	228 (5)	22 (7)	0.38
BPD, n (%)	2288 (51)	2035 (49)	253 (77)	<0.01
Severe IVH (grade III or IV) or PVL, n (%)	745 (16)	649 (15)	96 (29)	<0.01
Weight Z-score at 36 weeks, mean (SD)	−1.41 (0.83)	−1.39 (0.83)	−1.62 (0.87)	<0.01
Length Z-score at 36 weeks, mean (SD)	−1.94 (0.92)	−1.91 (0.92)	−2.26 (0.94)	<0.01
Head circumference Z-score at 36 weeks, mean (SD)	−1.34 (1.03)	−1.31 (1.03)	−1.71 (1.01)	<0.01
Outcomes at follow-up				
Weight Z-score at follow-up, mean (SD)	−1.02 (1.32)	−0.98 (1.30)	−1.59 (1.51)	<0.01
Length Z-score at follow-up, mean (SD)	−0.67 (1.31)	−0.62 (1.31)	−1.32 (1.18)	<0.01
Head circumference Z-score at follow-up, mean (SD)	−0.55 (1.62)	−0.49 (1.60)	−1.32 (1.69)	<0.01
Follow-up weight < 10th %, n (%)	1852 (41)	1669 (40)	183 (56)	<0.01
Follow-up height <10th %, n (%)	1255 (28)	1087 (26)	168 (51)	<0.01
Follow-up Head circumference < 10th %, n (%)	1216 (27)	1063 (25)	153 (47)	<0.01
Weight gain velocity[2] (g/mo), mean (SD)	414.53 (177.09)	416.24 (182.97)	394.78 (81.39)	<0.01
Length gain velocity[2] (cm/mo), mean (SD)	1.88 (0.74)	1.88 (0.76)	1.82 (0.24)	<0.01
Head circumference gain velocity[4] (cm/mo), mean (SD)	0.77 (0.30)	0.77 (0.31)	0.76 (0.15)	0.31
NDI[3], n (%)	1420 (31)	1217 (29)	203 (61)	<0.01
Moderate/severe cerebral palsy, n (%)	271 (6)	199 (5)	72 (22)	<0.01
BSID III Cognitive <70, n (%)	424 (9)	315 (8)	109 (34)	<0.01
BSID III Cognitive <85, n (%)	1300 (29)	1117 (27)	183 (56)	<0.01
BSID III Language <70, n (%)	787 (18)	646 (16)	141 (44)	<0.01
Chronic breathing problems, n (%)	1318 (32)	1139 (30)	179 (55)	<0.01
Chronic feeding problems, n (%)	1281 (28)	1085 (26)	196 (59)	<0.01

[1] n (%) and mean (SD) scores were calculated based on non-missing responses.

[2] Velocity is calculated from 36 weeks to follow-up.

[3] **NDI** was defined as any of the following: a cognitive composite score on the BSID III <85, moderate-to-severe CP, GMFCS level >2, severe hearing impairment, or bilateral severe visual impairment.

Table 2.

Associations between characteristics and GT placement

Variables	Odds Ratio (95% CI)[1]	P-Value
Gestational Age	0.91 (0.82,1.00)	0.06
Small for Gestational Age	1.92 (1.31,2.84)	<0.01
Male	0.89 (0.71,1.13)	0.34
White[2]	0.96 (0.75,1.24)	0.77
Hispanic	0.74 (0.51,1.06)	0.10
Maternal education (High School degree)[3]	0.98 (0.71,1.34)	0.88
Length of hospital stay	1.02 (1.02,1.02)	<0.01
NEC	1.13 (0.70,1.81)	0.61
BPD	2.94 (2.20,3.92)	<0.01
Severe IVH (grade III or IV) or PVL	2.01 (1.54,2.64)	<0.01
Weight Z-score at 36 weeks	0.65 (0.55,0.76)	<0.01
Length Z-score at 36 weeks	0.67 (0.58,0.78)	<0.01
Head circumference Z-score at 36 weeks	0.72 (0.64,0.82)	<0.01
Weight Z-score at follow-up	0.75 (0.69,0.82)	<0.01
Length Z-score at follow-up	0.77 (0.70,0.84)	<0.01
Head circumference Z-score at follow-up	0.77 (0.71,0.83)	<0.01
Follow-up weight < 10^{th} %	1.65 (1.30,2.10)	<0.01
Follow-up height < 10^{th} %	2.64 (2.07,3.36)	<0.01
Follow-up head circumference < 10^{th} %	2.02 (1.58,2.59)	<0.01
Weight gain velocity	1.00 (1.00,1.00)	0.25
Length gain velocity	0.96 (0.87,1.05)	0.36
Head circumference gain velocity	0.93 (0.71,1.21)	0.57
NDI	3.19 (2.49,4.10)	<0.01
Moderate/severe cerebral palsy	4.60 (3.25,6.50)	<0.01
BSID III Cognitive <70	4.93 (3.69,6.58)	<0.01
BSID III Cognitive <85	2.97 (2.31,3.81)	<0.01
BSID Language <70	3.53 (2.73,4.56)	<0.01
Chronic breathing problems	2.42 (1.89,3.10)	<0.01
Chronic feeding problems	4.06 (3.12,5.28)	<0.01

[1]Odds ratios were estimated using logistic regression models. Models included one characteristic at a time as the primary independent variable with center, gestational age, small for gestational age status, physiological bronchopulmonary dysplasia, medically managed necrotizing enterocolitis, and severe intraventricular hemorrhage or periventricular leukomalacia as covariates. Statistical significance was determined by Wald chi-square tests.

[2]Reference all “non-White” other than Hispanic

[3]Reference those without high school degree

Table 3.

Demographics of those with or without GT at follow-up.

Variables	No tube feeding at FU N=108	Tube feeding at FU N=225	P-value
Small for Gestational Age	12 (11)	26 (12)	0.99
Male	53 (49)	109 (49)	0.99
White	70 (67)	117 (53)	0.02
Hispanic	29 (27)	22 (10)	<0.01
High School degree	57 (72)	127 (75)	0.64
Length of hospital stay	158.20 (62.83)	174.68 (75.11)	0.08
NEC	9 (8)	13 (6)	0.48
BPD	75 (71)	178 (80)	0.07
Severe IVH (grade III or IV) or PVL	31 (29)	65 (29)	0.99
Weight Z-score at 36 weeks	−1.53 (0.86)	−1.66 (0.87)	0.22
Length Z-score at 36 weeks	−2.02 (0.88)	−2.38 (0.94)	0.14
Head circumference Z-score at 36 weeks	−1.58 (0.94)	−1.77 (1.04)	0.38
Weight Z-score at follow-up	−1.72 (1.42)	−1.53 (1.55)	0.17
Length Z-score at follow-up	−1.16 (1.11)	−1.40 (1.21)	0.48
Head circumference Z-score at follow-up	−1.18 (1.57)	−1.39 (1.74)	0.03
Follow-up weight <10th %	60 (57)	123 (55)	0.81
Follow-up height <10th %	51 (48)	117 (53)	0.48
Follow-up HC <10th %	43 (41)	110 (50)	0.13
Weight gain velocity (g/month)	381.73 (70.75)	401.04 (85.48)	0.19
Length gain velocity (cm/month)	1.80 (0.23)	1.84 (0.25)	0.74
Head circumference gain velocity (cm/month)	0.74 (0.14)	0.76 (0.15)	0.11
NDI	47 (44)	156 (69)	<0.01
Moderate/severe cerebral palsy	6 (6)	66 (29)	<0.01
BSID III Cognitive <70	16 (15)	93 (43)	<0.01
BSID III Cognitive <85	43 (40)	140 (65)	<0.01
BSID III Language <70	27 (25)	114 (55)	<0.01
Chronic breathing problems	39 (37)	140 (63)	<0.01
Chronic feeding problems	40 (37)	156 (69)	<0.01

Table 4.

Demographics of those who had GTs placed pre- and post-discharge

Variables	GT Pre-discharge N=81	GT Post-discharge N=252	P-value
Small for Gestational Age	9 (11)	29 (12)	0.99
Male	37 (46)	125 (50)	0.53
White	47 (59)	140 (57)	0.90
Hispanic	14 (18)	37 (15)	0.60
High School degree	45 (79)	139 (73)	0.39
Length of hospital stay (days)	163 (57)	171 (76)	0.99
NEC	6 (7)	16 (6)	0.80
BPD	58 (73)	195 (78)	0.29
Severe IVH (grade III or IV) or PVL	20 (25)	76 (30)	0.40
Weight Z-score at 36 weeks	−1.59 (0.96)	−1.63 (0.84)	0.39
Length Z-score at 36 weeks	−2.20 (1.05)	−2.28 (0.90)	0.89
Head circumference Z-score at 36 weeks	−1.72 (1.10)	−1.70 (0.99)	0.82
Weight Z-score at follow-up	−1.49 (1.39)	−1.62 (1.54)	0.98
Length Z-score at follow-up	−1.24 (1.16)	−1.35 (1.19)	0.30
Head circumference Z-score at follow-up	−1.04 (1.59)	−1.42 (1.71)	0.19
Follow-up weight <10th %	44 (55)	139 (56)	0.90
Follow-up height <10th %	36 (45)	132 (53)	0.25
Follow-up HC <10th %	33 (41)	120 (49)	0.30
Weight gain velocity (g/month)	401.78 (83.40)	392.49 (80.77)	0.38
Length gain velocity (cm/month)	1.87 (0.26)	1.81 (0.23)	0.76
Head circumference gain velocity (cm/month)	0.79 (0.15)	0.75 (0.14)	0.04
NDI	42 (52)	161 (64)	0.07
Moderate/severe cerebral palsy	12 (15)	60 (24)	0.09
BSID III Cognitive <70	24 (30)	85 (35)	0.50
BSID III Cognitive <85	39 (49)	144 (59)	0.12
BSID III Language <70	32 (40)	109 (46)	0.37
Chronic breathing problems	32 (42)	147 (59)	0.01
Chronic feeding problems	37 (46)	159 (63)	<0.01

Table 5.

Characteristics of those discharged on NG with or without GTs placed post-discharge.* (Online only)

Variables	Discharged on NG, no GT placed post-discharge N=18	Discharged on NG, GT placed post-discharge N=13	P-value
Small for Gestational Age	2 (11)	2 (15)	0.99
Male	12 (67)	3 (23)	0.03
White	11 (61)	8 (62)	0.99
Hispanic	1 (6)	2 (17)	0.55
High School degree	14 (93)	5 (63)	0.10
Length of hospital stay (days)	107 (9)	107 (10)	0.36
NEC	2 (11)	0 (0)	0.50
BPD	16 (89)	8 (62)	0.10
Severe IVH (grade III or IV) or PVL	2 (11)	6 (46)	0.04
Weight Z-score at 36 weeks	−0.92 (0.41)	−1.27 (0.66)	0.10
Length Z-score at 36 weeks	−1.53 (0.64)	−1.94 (0.87)	0.10
Head circumference Z-score at 36 weeks	−0.88 (0.68)	−1.35 (0.80)	0.18
Weight Z-score at follow-up	−0.47 (1.43)	−1.60 (1.55)	0.10
Length Z-score at follow-up	−0.17 (0.77)	−1.15 (0.77)	<0.01
Head circumference Z-score at follow-up	−0.07 (1.77)	−0.51 (1.11)	0.03
Follow-up weight <10th %	5 (28)	7 (54)	0.26
Follow-up height <10th %	1 (6)	6 (46)	0.01
Follow-up head circumference <10th %	3 (17)	2 (17)	0.99
Weight gain velocity (g/month)	448.44 (108.42)	389.59 (83.20)	0.36
Length gain velocity (cm/month)	1.93 (0.22)	1.83 (0.16)	0.10
Head circumference gain velocity (cm/month)	0.78 (0.08)	0.78 (0.14)	0.46
NDI <70	4 (22)	6 (46)	0.25
NDI <85	7 (39)	6 (46)	0.73
Moderate/severe cerebral palsy	2 (11)	1 (8)	0.99
BSID III Cognitive <70	3 (17)	2 (15)	0.99
BSID III Cognitive <85	6 (33)	5 (38)	0.99
BSID III Language <70	5 (28)	2 (15)	0.67
Chronic breathing problems	12 (67)	5 (38)	0.16
Chronic feeding problems	9 (50)	10 (77)	0.16

*Information regarding discharge on NG/NJ feeding was only available from January 2008 through June 2011.

Table 6.

Rate of GT placement and fundoplication by center (Online only)

Centers	Gastrostomy Tube Placement	Fundoplication
A	0/20 (0%)	0/20 (0%)
B	0/17 (0%)	0/17 (0%)
C	5/187 (3%)	2/187 (1%)
D	3/91 (3%)	0/91 (0%)
E	6/168 (4%)	2/168 (1%)
F	9/240 (4%)	2/240 (1%)
G	3/74 (4%)	1/74 (1%)
H	1/23 (4%)	1/23 (4%)
I	20/450 (4%)	3/450 (1%)
J	12/260 (5%)	6/260 (2%)
K	15/315 (5%)	2/315 (1%)
L	4/76 (5%)	3/76 (4%)
M	1/18 (6%)	1/18 (6%)
N	29/405 (7%)	12/405 (3%)
O	17/226 (8%)	8/226 (4%)
P	32/404 (8%)	7/404 (2%)
Q	19/232 (8%)	0/232 (0%)
R	10/119 (8%)	4/119 (3%)
S	9/96 (9%)	3/96 (3%)
T	34/342 (10%)	22/342 (6%)
U	22/201 (11%)	6/201 (3%)
V	26/231 (11%)	9/231 (4%)
W	5/37 (14%)	1/37 (3%)
X	50/312 (16%)	2/312 (1%)
Y	1/5 (20%)	0/5 (0%)