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Effective Tube Weaning and Predictive Clinical Characteristics of NICU Patients With Feeding Dysfunction

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Abstract

Background: The present study evaluated the effectiveness of a multidisciplinary earlier discharge model for neonates receiving home enteral nutrition (HEN). *Methods:* A retrospective data review and analysis was performed on 183 patients discharged out of the neonatal intensive care unit (NICU) receiving partial oral feeds (PO) and partial HEN from September 2016 to March 2018. These patients were followed in a multidisciplinary clinic led by a pediatric gastroenterologist, a neonatal feeding therapist, and a pediatric dietitian. Demographics and data were recorded for patients at discharge, and then chart reviews were performed for additional data. *Results:* Of 182 patients, 121 (67%) weaned off HEN with a median time to full PO at 79 days (interquartile range [IQR] 15, 247) and had median PO intake of 20% (0, 43) at time of discharge. When comparing patients who gained 100% PO vs patients who did not wean off HEN, the weaned group consisted of 88% nasogastric tubes, with median time off feeds at 27 days (IQR 8, 79) and median PO intake of 29% (11, 50) at discharge. Only 13% of the cohort had an emergency room or hospital admission, which corresponds to 1.6 and 0.8 events, respectively, per 500 tube days specifically due to HEN complications. *Conclusions:* Our study supports that NICU patients with feeding dysfunction can effectively and safely discharge home earlier while receiving HEN. Our data suggest that a dedicated outpatient clinic can facilitate effective tube weaning in a majority of neonates with complex medical diseases with low rates of adverse events. (*JPEN J Parenter Enteral Nutr.* 2019;00:1–8)

Keywords

dysphagia; enteral access; enteral nutrition; gastrostomy tube; GI access; home nutrition support; nasogastric tube; neonates; nutrition support teams

Clinical Relevancy Statement

Earlier discharge from the neonatal intensive care unit on home enteral feeding tubes is becoming more common, but outpatient outcomes have not been well researched and little has been published detailing the progress of feeding tube discontinuation in the outpatient experience. This paper gives outpatient clinical outcomes within the first several months after hospital discharge and their association with neonatal characteristics.

Introduction

Feeding and swallowing dysfunction is common in premature as well as full-term infants who require care in neonatal intensive care units (NICUs).[1-8] Many of these patients overcome other medical problems but remain in the NICU for a prolonged length of stay (LOS) in order to achieve full oral feeds (PO). Prolonged LOS for neonates has many risks, including but not limited to: increased risk of secondary infections, medical errors, barriers to breastfeeding, and developmental complications.[1,9,10] Recent improvements in early identification of feeding dysfunction have improved NICU outcomes, reduced LOS, resulted in earlier transition to PO, as well as obtained higher parental satisfaction after discharge.[7,10-17] Home enteral nutrition (HEN) discharge programs for earlier PO are now more common, after a neonate's stabilization of medical needs and proper home care teaching.[10,12,15-31]

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Although there is high recognition for feeding dysfunction and prolonged enteral tube needs in NICU patients, no standard in discharge criteria or postdischarge care for patients using either nasogastric tube (NGT) or gastrostomy tube (GT) fully exists. Our surgical-based and referral-based NICU inside our quaternary children's hospital sought to reduce variability in discharge criteria for patients who required HEN and streamline the outpatient treatment approach. We created a home enteral feeding transitions (HEFT) clinic with direct outpatient gastroenterology/nutrition care as part of a quality improvement (QI) program. The pilot HEFT cohort's inpatient outcomes demonstrated improvement in discharge standardization with excellent patient safety, parental satisfaction after hospital discharge, and a trend toward reduced LOS by project completion.[27]

The purpose of our present study was to evaluate the postdischarge clinical outcomes of these patients after leaving the NICU. We hypothesized that neonates could continue to be effectively discharged earlier—before majority of feeds by mouth were established—and wean off HEN at home. The secondary objectives were to identify infant characteristics and demographic factors at time of discharge that could impact how quickly patients may or may not achieve full PO after discharge and to report postdischarge adverse events (AEs).

Methods

We included clinical data from September 2016 to April 1, 2018, and included both the pilot program patients as well as subsequent patients discharged under the HEFT program for analysis. The Institutional Review Board at the University of Utah and Primary Children's Hospital reviewed our data collection and storage methods and approved the study for data review and analysis (#00113992). A pilot study of this patient population was performed from September 2016 to Mary 2017 (98 subjects).[27] Data from this early cohort showed no differences in the primary discharge diagnosis category (cardiac, gastrointestinal, neurologic, respiratory, or other) between patients discharged on partial HEN and those who took full PO, nor differences between diagnosis category and hospital LOS.

Post-discharge data were collected on patients through a median of 359 days (range 1, 561) postdischarge, per patient. Clinical and demographic details were obtained before and after hospitalization. Neonatologists selected patients using the established inclusion criteria and algorithm that identified who met earlier discharge on partial HEN (see Figure 1). The NICU case managers made first appointments in the HEFT clinic upon discharge for all patients to assist with outpatient clinic compliance. Before discharge, all parents/caregivers were taught NGT replacement using the method of measuring from nose to earlobe to xiphoid process to midway to umbilicus (NEMU method) and return of gastric contents to verify correct placement. Parents were individually taught and had to show competence with placement and replacement before discharge. After discharge, patients were provided home health nursing for a minimum of 3 weeks, which was prolonged as clinically indicated.[27] Patients were also provided early intervention visits upon discharge. No patient was discharged if caregivers were uncomfortable with NGT replacement or had further concerns.

Inclusion Criteria

- >37 weeks PMA
- No further medical contraindications to discharge
- Stable feeding method (either NGT or GT)
- Caregiver competence with discharge plan and tube replacement if NGT

Exclusion Criteria

- Presence of craniofacial abnormalities precluding safe HEN replacement
- Transpyloric feeding tube

Figure 1. Criteria for HEFT Selection. GT, gastrostomy tube; HEFT, home enteral feeding transition; HEN, home enteral nutrition; NGT, nasogastric tube; PMA, postmenstrual age.

To provide a representative cohort, no patients were excluded from the HEFT program based on diagnosis or medical complexity alone. If patients were not seen in clinic, a follow-up phone call by the outpatient clinic scheduler was made to ensure the patient had follow-up elsewhere (skilled pediatrician or subspecialty provider), and to verify enteral tube use.

After discharge, we centralized these patients in a post-NICU follow-up clinic (HEFT clinic) to assist families with tube weaning, nutrition, and gastrointestinal cares. The HEFT clinic utilized a single pediatric gastroenterologist, developmental feeding therapist, and pediatric dietitian with each visit. In terms of tube weaning support, we did not create a standardized protocol for this process given lack of medical evidence for neonatal tube weaning.[16,31] All patients were treated individually according to their age, developmental needs, comorbidities, and feeding ability. With the assistance of the neonatal feeding therapist, reductions in tube dependence were made as the patient demonstrated improved and increased oral skills. Typical methods for feeding advancement included some of all of the following: gradual advancement of bottle or cup feeds with patient development, utilization of formula thickeners, and increased frequency of feeding therapy sessions (home or outpatient). Referrals for additional needs (eg, home health, therapies, surgical GT placements) were continued or initiated at HEFT clinic visits.

Table 1. Clinical Characteristics of HEFT Patients and Patients Who Weaned Off HEN and Those Who Did Not Wean Off HEN.

Clinical Characteristics	HEFT Cohort	Tube Weaned Group	Non-Weaned Group	*P*-Value
n (%)	182	121 (67)	61 (34)	
NGT, n (%)	110 (60)	106 (88)	4 (6)	<0.001
Male sex, n (%)	108 (59)	74 (61)	34 (56)	0.482
Birth weight, g (IQR)	2428 (1380, 3185)	2510 (1550, 3385)	2270 (1130, 2930)	0.035
LOS, d (IQR)	38 (19, 87)	33 (17, 67)	55 (24, 124)	0.003
PMA at discharge, wk (IQR)	43.6 (41, 46.9)	42.9 (40.6, 45.3)	45.6 (42.4, 52.7)	<0.001
Gestational age at birth, wk (IQR)	36 (30, 38)	36 (31, 38)	36 (27, 38)	0.443
PO at discharge, % (IQR)	20 (0, 43)	29 (11, 50)	0 (0, 10)	<0.001
Weight at discharge, g (IQR)	3765 (3160, 4540)	3700 (3180, 4355)	3975 (3085, 5315)	0.078
Follow-up weight-for-length,* *z*-score *n = 168	−0.06 (−0.82, 0.88)	−0.28 (−0.88, 0.69)	0.16 (−0.63, 1.14)	0.082

g, grams; HEN, home enteral nutrition; IQR, interquartile range; LOS, length of stay; NGT, nasogastric tube; PO, oral intake; wk, weeks.
* = different n

For AEs, chart review for emergency room (ER) presentation and/or hospital admission because of HEN complications or events was performed for all patients up to 6 months after NICU discharge. ER visits that led to admission were not duplicated within the ER counts. All discharge notes were reviewed to ensure the AE was related to HEN or growth events, specifically.

Statistical Analyses

We categorized patients by gestational age, birth weight (BW), postmenstrual age (PMA), PO at discharge, and LOS. PMA was used in addition to LOS, given that this NICU population was a referral-based center with many non-premature infant admissions. Nonparametric variables were reported as medians with interquartile range (IQR). Categorical variables were recorded as counts. Statistical analysis for data was performed with Wilcoxon rank sum test, χ^2 analysis, and Kruskall–Wallis method where appropriate. Kaplan–Meier survival curves were performed for nonparametric data with binary outcomes. AEs were reported as incidence rates and densities. All statistical analyses were conducted using STATA v. 15.0 (StataCorp, LLC, College Station, TX). Significance was reported at the 0.05 level, and all tests were 2-tailed.

Results

One hundred eighty-three patients met discharge criteria with HEN. We obtained tube data on 182 patients, and follow-up weight data were available on 168 patients. Table 1 presents patient characteristics and results between groups. Sixty-seven percent (N = 121) of patients with a median PO of 20% at time of discharge were able to discontinue HEN at 79 days postdischarge (IQR 15, 247).

The weaned group consisted of 106 (88%) NGT patients at discharge, and their median time to tube discontinuation was 27 days (IQR 8, 79). Only 2 NGT patients converted to GT after discharge, both of which occurred at >4 months because of parental request. The patients who successfully weaned off tubes had a median PO at discharge of 29% (11, 50) vs 0% (0, 10) in the non-weaned group ($P < 0.001$). The weaned group also had greater BW ($P = 0.035$), reduced LOS ($P = 0.003$), and lower PMA at discharge ($P < 0.001$) compared with the non-weaned group.

Within the group that did not wean, 23 (38%) patients converted to a GT after hospital discharge with a median time to GT placement at 123 days (IQR 84, 164). For this group, the median PO at discharge was 0%. Only 4 patients in this group remained with NGT at the end of study timeline. Of these 4 patients, 2 had Prader–Willi syndrome, 1 had a large omphalocele in which GT was contraindicated, and 1 patient's parents continued NGT out of preference.

Figure 2 shows the survival curve for tube discontinuation of the group who weaned, based on a patient's PO at discharge. We stratified these groups by quartiles of intake (eg, the first quartile of patients took 11% or less, the second quartile took between 12% and 29% PO, etc). Outside of the first 2 quartile groups, each quartile was significantly different ($P < 0.05$) in weaning time. Figure 3 shows the survival curve of tube discontinuation according to the PMA of patients at discharge. We stratified by infants discharged by term, within 1 month of term dates, and >1 month after term. These groups were all significantly different among each other.

In terms of growth, we used follow-up weight-for-length measurements within 6 months of discharge, which would adjust for premature growth, and found a median *z*-score of −0.06 (IQR −0.82, 0.88) (see Table 1). Between the group that weaned vs the non-weaned group, there was no difference in their follow-up *z*-scores ($P = 0.08$). We also illustrated the cohort's growth velocity during the same follow-up period. There were 11 patients (6.5%) with a weight-for-length *z*-score of −2 and smaller; 8 of these ultimately weaned from their tube (mean = 37 days; range

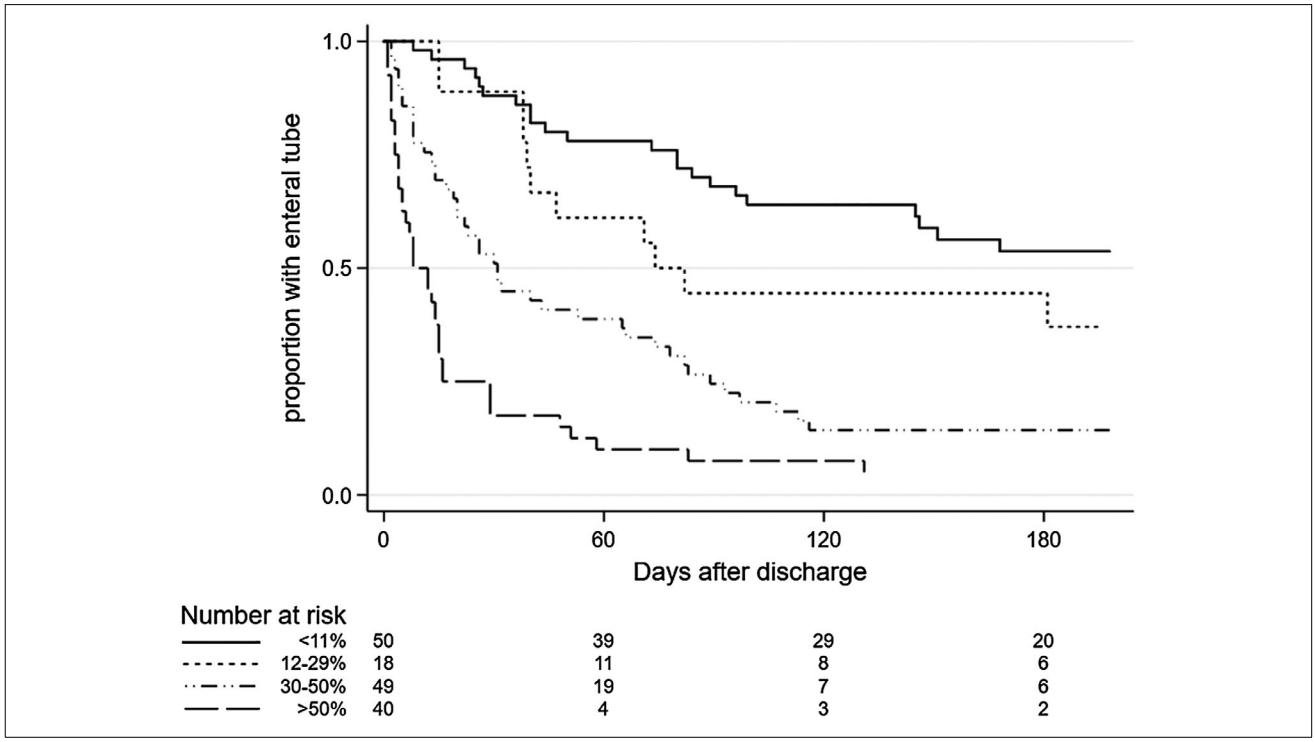

Figure 2. Time to tube discontinuation based on percent oral intake (by quartiles) at discharge. All quartiles statistically different from one another (P-value < 0.05) except for groups <11% and 12%–29%.

3, 180) with 1 Prader–Willi patient who did not wean and kept NGT. Only 1 patient subsequently had GT placement. None of these patients were admitted for malnutrition or feeding concerns.

Table 2 shows patients according to their BW classification and time to HEN wean. When analyzing among these groups using multiple group comparisons, there was a trend toward differences in groups ($P = 0.06$) but no clear pattern between their BW and the time to tube wean.

For AEs, there were 24 (13%) presentations to ER or hospital admission postdischarge for HEN complications. There were no deaths (because of HEN or otherwise) during the study period in our cohort. Fifteen (8%) patients had an ER visit, in which 8 (4%) were due to GT complications, 4 had NG/NJ complications, 2 were referred for poor growth (but not admitted), and 1 patient's parents were uncomfortable with feeding equipment. For hospital admissions, 9 (5%) were admitted. Of these, 8 patients were admitted for poor growth in which 1 of these had a subsequent GT placement. All admissions for poor growth were discharged <72 hours after admission. One patient had aspiration pneumonia because of the parent not thickening feeds as instructed.

When we analyzed our AEs against tube exposure for patients, we recorded 25,710 tube days for all patients during the study period. This gave an incidence density of 1.6 ER visits and 0.8 admissions per 500 tube days because of HEN complications.

Discussion

Through this study, we demonstrate safe and effective earlier discharge in patients with feeding dysfunction. We feel our study and its favorable findings in regard to associations of PO intake, increased BW, reduced PMA, and shorter LOS at NICU discharge can help guide parents and practitioners on the prognosis of their neonate overcoming HEN in the home setting. We believe it is also helpful to show that the group that could not wean HEN had a median PO of 0% at discharge, and this group could be counseled that they will most likely have prolonged HEN dependence and that earlier discharge to the home setting with feeding therapies may be preferred to prolonging hospitalization.

To the best of our knowledge, we are the first to show safety results of HEN with incidence of overall tube day exposure in the complex neonatal population. Our safety data in regard to ER or hospitalizations are improved from previous literature and suggest that caregivers are equipped to transition home with either NGT or GT methods without increased complications.[32-34] Also, our overall patient population did not have failure of growth. Although there was a trend toward lower z-scores for weight-for-length in the group that weaned off their tubes, again, there was not an increased incidence of hospitalization in these patients. Further prospective cohort studies will help to address these clinical outcomes.

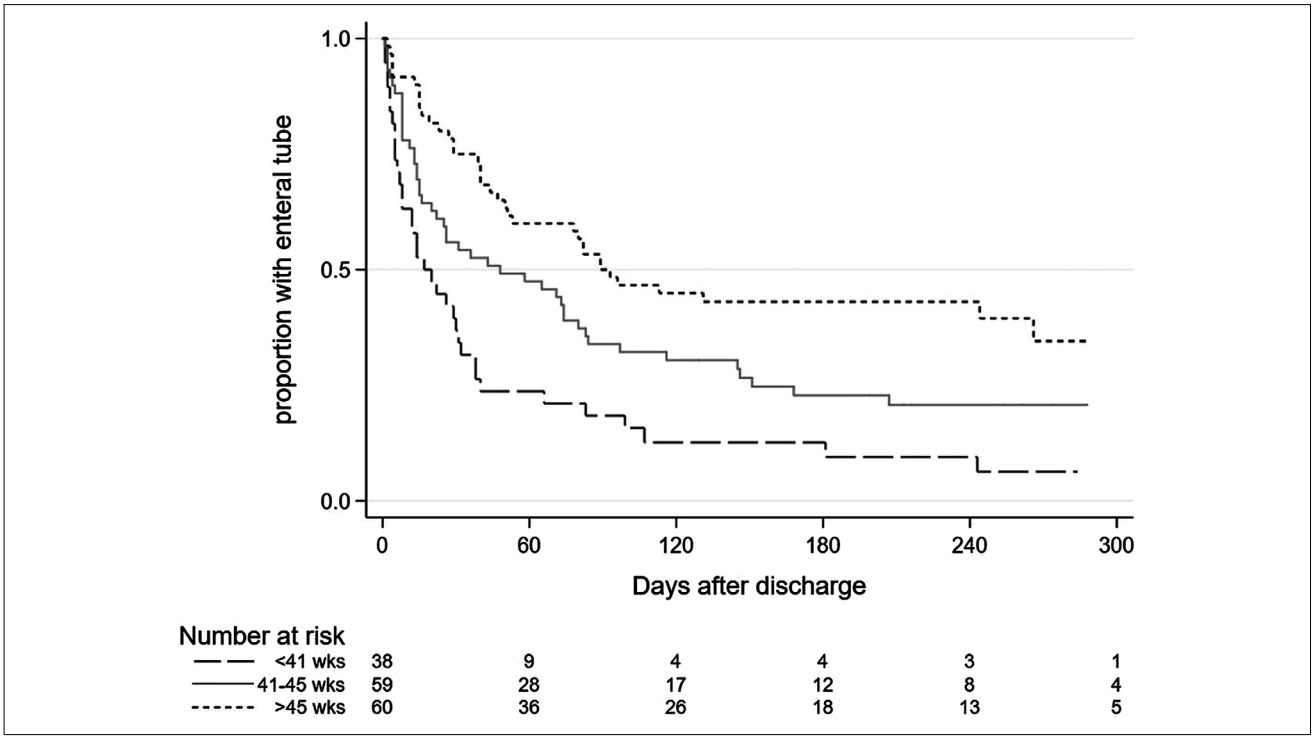

Figure 3. Time to tube discontinuation based on postmenstrual age at discharge. All groups statistically different from each other (P-value < 0.05).

Table 2. Days to Tube Wean Based on Birth Weight Category.

Birth Weight Category, g	n (%)	Days After Discharge to Tube Wean, (IQR)
ELBW (<1000)	27 (15)	216 (65, 360)
VLBW (1000–1500)	23 (13)	53 (11, 123)
LBW (1501–2500)	44 (24)	83 (15, 266)
SBW (>2500–4000)	88 (48)	40 (15, 247)
HBW (>4000)	10 (6)	55 (19, 80)

ELBW, extremely low birth weight; HBW, high birth weight; IQR, interquartile range; LBW, low birth weight; SBW, standard birth weight; VLBW, very low birth weight.

Our findings are similar to a previous study that showed patients with NGTs weaned off feeds earlier and had increased PO feeding at discharge.[32] However, this retrospective study compared patients based on tube types at discharge (NG vs GT), as opposed to our approach of evaluating the differences among patients who did and did not wean off tube feeds after discharge.

We also showed that for many patients who require HEN, given that 75% of this group will not require feeding tubes by 80 days postdischarge, NGT use at home is appropriate, and many patients could forego GT placement. Furthermore, our experience suggests that many patients (≈20% in our cohort), despite having an NGT longer than 90 days, will still wean successfully, thus obviating the need for gastrostomies. This is somewhat in contrast to previous literature that suggests gastrostomy placement be considered after 4–6 weeks of NG tube use.[32,33,35] Additionally, our postdischarge GT complication rate was quite different from previous findings in the Khalil paper, which had a rate of 34% GT-related ER visits compared with 4% in our cohort. Given that existing literature shows that G-tube complications account for increased medical utilization,[32-34,36,37] our study supports that complications could be avoided altogether without unnecessary placement.

We acknowledge that some patients may ultimately benefit from GT placement, and this study's data try to further determine which clinical variables may add to this prognostic dilemma. However, our institution also supports the concept of shared decision-making with parents, given that there are no current diagnostic nor prognostic guidelines that accurately predict the best candidates or timing for GT surgery. This process is similar to a recent commentary by Lee and Cordon supporting an article by Nelson et al on the association of increased mortality rate in children with GT and neurologic impairment.[37,38] Lee and Cordon propose that GT placement is a complex decision that should be incorporated with families' values, given the inherent risks of medically-complex children who warrant GTs. We also propose that returning for an outpatient GT placement after NICU discharge does not reflect failure

of oral feeding efforts but rather that these patients can discharge home safely on NGTs, work on growth and recovery from their NICU diagnoses, and have an outpatient surgical GT placement as larger, healthier infants, which could reduce associated surgical morbidities and mortality.

Our study is also relevant given that there are known associations of healthcare cost and utilization burden of NICU infants both during and after their admission.[19,22,26-30,39-48] Our multidisciplinary program for NICU graduates follows current recommendations for comprehensive outpatient care, but we are the first to show outpatient HEN weaning support, which is a high percentage of the post-NICU burden at home. Although we have not yet analyzed the cost savings of our cohort, we are encouraged that a program such as ours has significant savings from reduced LOS, avoidance of invasive procedures (eg, GT placement), outpatient complications, or fragmented healthcare delivery. The preliminary study by White et al did show this trend toward reduced LOS and its cost savings after discharge.[27]

We recognize several limitations to this study. By including the initial program patients in our analyses, our results most likely skewed our LOS data, given that not all neonatologists were comfortable with the earlier discharge criteria. As the neonatologists' familiarity with the program's effectiveness and implementation grows, we presume our patients' outcomes will follow these trends.

Other limitations include the lack of an established feeding protocol for this age group and patient population, which means there may be some patients who may have been able to wean sooner, whereas others may have converted to GT earlier. For example, our data showed that 28% of the weaned group discontinued HEN within 10 days after discharge. Of these patients, 2 had a subsequent admission for gastroenteritis and 2 had hospitalization for bronchiolitis, but none had malnutrition or poor growth. Although these data do support our discharge program's intent to reduce the hospital LOS if feeding dysfunction was the only remaining inpatient need, this patient group may also have remained in the NICU for alternative diagnosis reasons (not just feeding dysfunction), and we recognize the possible bias in these results. Rather than utilizing a specific nutrition or therapy-driven weaning protocol, our intent was to provide consistent outpatient providers to limit fragmented practices as well as home services for these high-needs patients and families. Future prospective studies could answer these gaps in medical knowledge.

Furthermore, we recognize the heterogeneous nature of patient complexity and comorbidities with regard to our results. We did not analyze patients by their comorbidities or presumed cause of feeding dysfunction, as this has been previously documented with the original HEFT QI project[27] and prior studies and reviews.[7,8,32,33,37] One recent 2019 article by Park, Thoyre, Pados, and Gregas demonstrates that premature infants with prolonged feeding dysfunction have associations such as prolonged oxygen need, congenital heart disease, and genetic syndromes.[8] We clarify that our study's purpose was not to highlight specific diagnosis associations but rather look at the complex NICU referral cohort as a whole to determine what other factors may be involved with feeding dysfunction, regardless of underlying disease. Our data also did not show an association between BW categories and time to tube weaning, which again is probably confounded by the quaternary NICU setting. Follow-up studies using non-referred newborn ICU settings could provide better prognostic data on feeding outcomes for premature-only populations, as their needs and outcomes may differ.

Lastly, we realize the limits because of the observational nature of our data, in regards to our outcome results, although with scheduling follow-up, we were able to capture tube discontinuation dates in a prospective manner for all patients. Also, with retrospective review, our AE reporting is most likely an underestimate, given that any patient presentation to a non-Intermountain Healthcare facility or primary care office is not reflected through our medical records. Yet, our records would capture any pediatric admission within the region since Intermountain Healthcare is the only regional provider for pediatric hospital care.

In conclusion, this paper highlights that earlier discharge on HEN for neonates with feeding dysfunction is appropriate and safe, even in the setting of complex medical disease. With the support of an outpatient postdischarge clinic and therapies, most patients develop adequate feeding skills without requiring GT placement or intensive feeding therapy. This combination of appropriate patient identification and a consistent outpatient approach decreases healthcare utilization, increases parental satisfaction, and allows successful HEN weaning during a neonates' first year of life.

Statement of Authorship

A. Ermarth, B. R. White, C. Y. Ling, and D. Thomas equally conceptualized and contributed to the study and its design; A. Ermarth, B. R. White, A. Cardullo, and D. Thomas participated in data collection and acquisition; and A. Ermarth drafted the initial manuscript and performed statistical analyses. All authors critically reviewed and revised the manuscript, agree to be accountable for the integrity and accuracy of the work, and approved the final version as submitted. A preliminary version of this work was presented at the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition Annual Meeting (Hollywood, Florida, USA) October 25-27, 2018, for whom A. Ermarth received a small monetary travel grant award for her original work.

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