Variables Impacting the Time Taken to Wean Children From Enteral Tube Feeding to Oral Intake

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ABSTRACT

Objectives: This study investigated biological factors, which may influence the time taken for children to wean from enteral to oral intake.
Methods: Retrospective case-note audit of 62 tube-fed children (nasogastric or percutaneous endoscopic gastrostomy) aged 6 months to 8 years, participating in an intensive tube weaning program. Program design included family-focused mealtimes, child autonomy, and appetite stimulation. A regression model was developed, which shows the combination of variables with the most predictive power for time taken to wean.
Results: Data from 62 children who were highly dependent (minimum 93% of calories provided enterally) on tube feeding for an extended period of time (mean = 2.1 years) were analysed. Children's mean body mass index z score at time of weaning was −0.47 (standard deviation 1.03) (mean weight = 10.54 kg) and 54 (87%) presented with a range of medical conditions. Forty-four children (71%) remained completely tube free at 3 months postintervention and an additional 5 children (10%) were fully tube weaned within 10 months of program commencement. Type of feeding tube, medical complexity, age, and length of time tube fed all significantly correlated with time taken to wean. Logistic regression modelling indicated that the type of feeding tube in combination with the degree of medical complexity and time tube fed were the strongest predictors of time taken to wean.
Conclusions: Biological factors usually considered to impact on successful weaning from tube feeding (volume of oral intake, oral skill, or mealtime behaviours) were not relevant; however, the type of feeding tube in combination with the degree of medical complexity and time tube fed were the strongest predictors. The impact of psychosocial factors should be investigated to identify if these mitigated the effects of the biological variables.

Key Words: clinical indicators, inpatient, oral intake, paediatric, tube weaning

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What Is Known

- Enteral tube weaning can be a complex and emotional process.
- Medical, psychological, emotional, oral motor, oral sensory, gross tumor, nutritional, and care giver capacity all affect a child's ability to learn to eat orally.
- Varying approaches are used to teach tube-fed children to eat.
- Interdisciplinary intensive tube-weaning programs are successful in tube weaning.

What Is New

- Prior oral experiences, mealtime behaviours, and amount consumed orally before weaning do not affect the time taken to wean.
- Combination of type of tube, length of time tube fed before weaning, and complexity of medical conditions provide the strongest predictors of time taken to wean. Less medically complex children fed by nasogastric tubes wean more quickly.
- Body mass index z scores do not predict the length of time to transition to oral feeding.

Infants born with chronic medical conditions are surviving in greater numbers due to improved medical treatment and technology (1). Subsequently, the use of enteral tube feeding has increased in children experiencing prematurity, physical, anatomical or neurological anomalies, metabolic diseases, conditioned dysphagia, severe paediatric disorders, and nonorganic failure to thrive (2–4). Tube feeding frequently persists beyond medical stability due to behavioural and stress responses (5–7). Internationally, approximately 4/100,000 children require enteral tube feeding (8), which is costly; affects social, psychological, medical, and general development; and causes high levels of parental emotional and psychological stress (9,10).

Weaning a child from tube feeding is complex and stressful due to multiple variables, which may influence the delicate process of transitioning from tube to oral intake. Internationally tube weaning practices comprise behavioural (11,12), multidisciplinary child initiated (8,13–16), or netcoaching approaches (17). Most involve hunger provocation through varying enteral feed volumes and are implemented in a variety of settings including community clinics, hospital (inpatient and outpatient), and home (12,15,17–19).

Variables that influence weaning include the child's medical complexity, type of tube used for feeding, and age (20,21). Therapists may also consider weaning success to be influenced by the

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child's preweaning ability to accept and swallow food/fluid, sensory and regulatory capacity, and oral motor skills.

This study investigated biological variables which may affect the time taken to wean children participating in an intensive interdisciplinary inpatient tube weaning program.

METHODS

Research Design

A retrospective audit was conducted on clinical files of 62 children who accessed an intensive weaning program from November 2010 until August 2016.

Inclusion/Exclusion Criteria

Data were included from all children from birth to 8 years of age who commenced phase 1 and 2 of the intensive tube weaning program within the audit time frame. Demographics of the children included are presented in Table 1.

Description of Intervention Program

The intensive intervention program was conducted in close collaboration with the families. It was supported by an interdisciplinary team led by a speech-language pathologist and included a dietitian, infant mental health specialist (IMH), paediatrician, occupational therapist (OT), and nurses. The underlying principles used to guide all stages of the weaning program were family focused mealtimes, child autonomy, appetite stimulation, and educating parents/carers to facilitate successful mealtimes by exploring and supporting the parent/child relationship. The intervention comprised 3 main phases: assessment and development of weaning readiness; intensive weaning; and maintenance.

Once the child's medical practitioner consented to weaning, comprehensive assessment undertaken by a speech-language pathologist, dietitian, and OT explored medical and developmental background, historical and current tube feeding practices, current feeding regime, calories and growth, oral acceptance of food and/or fluids, mealtime behaviour, sensory processing, and seating. Oral skill, precursors to oral acceptance (self-initiating interaction with food, exploring food, eye gaze), swallowing safety, sensory tolerance, and parental engagement were directly assessed by the appropriate discipline using a combination of standardized (eg, Winnie Dunn Sensory Profile (22)), observation, questionnaire (23), and clinical assessments (oral motor, video fluoroscopy swallow study where clinically indicated). Assessment findings were used to develop strategies in the home environment before intensive therapy. Families met with the IMH therapist (OT, Diploma in Infant Mental Health and 25 years mental health experience). The IMH therapist's role in the weaning process is to support parents in establishing and restoring the relational foundation of successful mealtime interactions and behaviours.

Readiness for the next intensive weaning phase was based on the following factors: medical stability defined as no acute medical complications or pending investigations/surgery and health had remained stable over at least the last 2 to 3 months; no diagnosed dysphagia; weight maintenance; plateau of mealtime skill through outpatient treatment; and parental capacity/readiness and overall family context to support transfer of skills to home environment (eg, moving house, new job).

When deemed by the team as ready to wean, the dietitian developed a 3-day prewean gradual reduction to 40% of the child's typical daily calories with overall fluid volumes being maintained via electrolyte solution. This commenced within the child's home and facilitated maintenance of fluid and electrolyte balance whilst reducing overall calories (see Table, Supplemental Digital Content 1, *http://links.lww.com/MPG/B618*, which outlines the hunger provocation, therapy, and follow-up program). The child was then admitted to a paediatric ward and reviewed medically by nursing staff and a paediatrician. Medical review by the paediatrician continued with daily monitoring of hydration status (physical), glucose (via glucometer), weight, stooling pattern (parental report), urine output (fluid balance chart), and the overall health of the child.

TABLE 1. Overview of the participant characteristics

Participant characteristics	
Sex	28 Female, 34 male
Age at commencement of prewean, y	Mean 2.4 (SD 1.71) range 0.6–7.7
Level of prematurity (WHO preterm birth categories)	Group 1, extremely preterm (<28 wk): n = 13 (21%) Group 2, very preterm (28–32 wk): n = 5 (8%) Group 3, moderate to late preterm (32–37 wk): n = 9 (15%) Group 4, term (>37 weeks): n = 35 (n = 56%)
Type of enteral tube feeding	32 NG, 30 PEG
Length of time tube fed before weaning, y	Mean 2.1 (SD 1.75) range 0.21–7.5
BMI *z* score at prewean	Mean −0.47 (SD 1.03)
Weight (kg) at prewean	Mean 10.45 (SD 2.98)
Percentage of required calories provided via tube feeding at prewean	93% (SD 21.12)
Coexisting medical factors	54 Children (87%) had coexisting medical factors in isolation or conjunction comprising: Neurological disorder: n = 10 (16%) Chromosomal disorder: n = 24 (39%) Malformation or disease of oral/GI tract complications: n = 15 (24%) Congenital metabolic conditions: n = 5 (8%) Congenital heart disease: n = 25 (40%) Respiratory complications: n = 27 (44%) Food allergies: n = 7 (11%) Cancer: n = 1 (1%)

BMI = body mass index; GI = gastrointestinal; NG = nasogastric; PEG = percutaneous endoscopic gastrostomy; SD = standard deviation.

Hunger provocation via graded reduced tube-feed volumes continued over the subsequent 7 days of admission to assist with motivation to eat by experiencing the consequence of hunger and the fulfilment of oral intake. Additional tube feeds were administered overnight (if required) at an amount and rate calculated as suitable for hydration, to manage extensive weight loss and maintain blood glucose levels based on oral intake that day. Weight loss of up to 10% from the start of the prewean weight was accepted (19,24). Nasogastric (NG) tubes were physically removed when glycaemic levels and hydration were stable. Daily bare weight before breakfast was recorded by nursing staff and parents/therapists recorded daily food/fluid intake and urine/stool output.

All mealtimes/snacks were provided in a family mealtime environment (including siblings) with a team member supporting and coaching. No force feeding was allowed. Mealtimes lasted 10 to 15 minutes initially, extending to 20 to 25 minutes by program completion. The child was offered textured food that they would be able to self-feed, matched their level of oral-motor skill and their sensory preferences. Food was offered on 5 structured occasions each day in a range of venues (hospital, café, playground, restaurant) with fluids offered via milk, bottle, or breast as required. Parents met with a team member for a debriefing after each meal.

Children were discharged from the intensive component of the program after 7 days with their tube feeds either removed or reduced/eliminated, with weight loss plateauing, blood glucose levels stable following overnight fasting, and hydration deemed medically adequate. Medical care was transferred back to the child's medical practitioner.

All children were reviewed (via Skype or in clinic pending proximity to the clinic) weekly then fortnightly for 3 months after completion of the intensive part of the program, with further support, advice, and tube feed reduction provided once established back in the home environment. The child's weight, height, oral and mealtime behaviours, urine and stool output, general development, sleep, and behaviour were monitored. Ongoing strategies around mealtime and food/drink behaviours, specific food suggestions, and enteral feed volumes (if required) were given and emotional support to parents. Children in this study were deemed as weaned when they no longer required any food or fluid via their tube and could maintain their growth and nutrition on oral intake alone.

Audit Methodology

Ethics approval was obtained from appropriate local human research ethics committee. Variables of interest were extracted from clinical files from the prewean assessment and the 3-month review. Variables were selected based on research evidence regarding impact on weaning outcomes (19,24) and those commonly thought clinically to influence and included age, sex, level of prematurity, weight, type of enteral tube, length of time tube fed, medical conditions, mealtime and oral behaviours/skill, and time taken to wean.

Classification of Variables for Analysis

Oral skills, mealtime/food interaction behaviours, and medical complexity were classified to allow grouping of children into descriptive categories for analysis. The rating charts for oral skills and mealtime/food interaction were developed by 2 speech pathologists with a minimum 10 years paediatric feeding experience. Each child's information was extrapolated from clinical files and rated. Medical complexity classifications were completed independently by 3 experienced allied health professionals with a minimum 10 years paediatric feeding experience. The majority consensus for the medical classification was accepted.

Oral skills were classified into 10 ordinal categories to reflect the typical development and clinical judgement of the specificity, complexity, and functionality of oral movements required for swallowing different textures, liquids, and/or combinations of these (Table 2).

Mealtime feeding/food interaction behaviour variables were classed into 5 categories (Table 2) which clinically represented different stages of food interaction commonly observed in the children seen in this program.

TABLE 2. Rating system used to categorize variables into oral experiences; mealtime feeding/food interaction behaviours; and medical complexity

Oral skills	**Rated 1–10 where 1 indicates best performance and 10 indicates poorest**
	1. Manipulates and swallows soft chew diet and thin fluids
	2. Manipulates and swallows mashed diet, dissolvable finger foods and thin fluids
	3. Manipulates and swallows puree diet, dissolvable finger foods and thin fluids
	4. Manipulates and swallows soft chew diet plus thickened fluids
	5. Manipulates and swallows mashed diet, dissolvable finger foods, and thickened fluids
	6. Manipulates and swallows puree diet, dissolvable finger foods, and thickened fluids
	7. Swallows liquids (thin)
	8. Swallows liquids (thickened)
	9. Mouths and tastes foods/fluids but doesn't swallow
	10. Complete refusal of all foods/fluids
Mealtime feeding/food interaction behaviours	**Rated 1–5 where 1 indicates best performance and 5 indicates poorest performance**
	1. Participates in oral food and drink experiences and allows adult involvement
	2. Accepts self-feeding (spoon, cup/bottle, or finger foods) but refuses adult attempts to assist with or encourage feeding
	3. Happily explores food/drinks by self, in a sensory manner but minimal amount ingested
	4. Minimal spontaneous interest/awareness in oral food/drink; passive acceptance; high level of distraction required
	5. Upset at food/drink offerings (including obstructive feeding behaviours such as gagging, vomiting at sight of food, throwing food, screaming in highchair)
Impact of medical complexity on weaning (rating scale)	0. No diagnosed medical condition but requiring a tube due to faltering growth
	1. Least impact on weaning (ie, predicted easiest to wean)
	2. Moderate impact on weaning
	3. Severe impact on weaning (predicted hardest to wean).

The type of medical condition(s) is likely to affect differently on feeding abilities and behaviours; therefore, summing the raw number of medical challenges was not considered meaningful. A 4-point rating scale was developed to represent the anticipated impact of each child's medical condition(s) on the weaning process (Table 2). The professionals' ratings for each child were summed, creating a weighted score. As the participant sample was small, these resulting groups were collapsed into 2 categories for regression analysis as "mild impact" (0 and 1) and "moderate to severe impact" (2 and 3) on weaning (see Appendix, Supplemental Digital Content 2, *http://links.lww.com/MPG/B619*, for development of classification for medical conditions).

Level of prematurity was classified against WHO preterm birth categories of (group 1) extremely preterm (<28 weeks), (group 2) very preterm (28–32 weeks), (group 3) moderate to late preterm (32–37 weeks), and (group 4) term (25). These categories were collapsed into 2 groups for analysis with categories 1 and 2 in one group and categories 3 and 4 in the other.

Data Analysis

Data were analysed using SPSS for Windows, version 23 (IBMSLPSS, Chicago, IL). Individual variables expected to influence the weaning process were analysed using univariate Cox regressions first to decide, which variables to include in subsequent logistic regression analysis. Variables that had a significant impact on the time taken to wean were type of feeding tube; medical complexity; age; and length of time tube-fed (all $P < 0.05$; Table 3 and Table, Supplemental Digital Content 3, *http://links.lww.com/MPG/B620*). In order to avoid effects of multicollinearity, nonparametric analyses of the relationships between age and duration of tube feeding was then undertaken which showed a high correlation between these variables (Spearman $r = 0.89$, $P < 0.001$). Therefore, only length of time tube-fed was included in the final regression model as this variable was deemed a potential predictive variable that is clinically easily assessed and the sample size did not allow for a larger number of variables to be included.

Variables that individually did not impact time taken to wean in the preliminary Cox regressions were excluded from further analyses (summarized in Table, Supplemental Digital Content 3, *http://links.lww.com/MPG/B620*).

Prematurity level was investigated to identify if it interacted with the level of medical complexity; however, this was not found to be the case ($B = -0.60$; SE = 0.65; $P = 0.362$; Exp (B) = 0.55; 95% confidence interval for Exp (B) = 0.15/1.99; $X^2 = 0.41$). Therefore, prematurity level was not considered in subsequent analyses.

Descriptive statistics explored the number of children weaned through the program and growth post weaning.

Finally, a 3-step logistic regression model was developed that incorporated the variables of time tube-fed before wean, medical complexity, and type of tube to determine the strongest predictors of time taken to wean. The logistic regression analysis was followed by an evaluation with survival analyses of the 2 different types of tubes and levels of medical complexity to quantify the effects of tube type and medical complexity on time taken to wean (Table 3).

RESULTS

Data from 62 children were available (mean age 2.4 year, standard deviation [SD] 1.71, age range 6 months to 7 years, 7 months; 28 girls; 32 fed via NG tube, 30 fed via PEG). All children were initially highly dependent on tube feeding with 93% (SD 21.12) of calories being provided via the tube for a mean time of 2.1 years (SD 1.75; range 0.2–7.5 years). Fifty-four children (87%) had at least 1 diagnosed medical condition. The mean weight at time of weaning was 10.54 kg (SD 2.98) and mean body mass index z score was −0.47 (SD 1.03). Mean score for prewean mealtime behaviours was 2.63 (SD 1.32) and 5.66 (SD 2.6) for oral experiences.

By completion of the 7-day intensive period 37 children (60%) were fully weaned with this number increasing to 45 children (73%) by 3 months and 50 children (81%) within 10 months of commencing the weaning process. By 3 months after discharge, 97% of weaned children remained on exclusive oral intake. Thirty-one children (69%) had exceeded or remained within 100 g of their prewean weight and the remaining 14 children were within 10% of their prewean weight. The mean weight loss during the 7-day intensive period was 2.75% (SD 2.19) of the child's prewean weight and by 3 months postdischarge the mean weight was a 3% gain from prewean weight (SD 1.84).

Children with NG tubes (mean 13.8, SD 11.14) had been tube fed for a significantly shorter time ($P < 0.001$) than children with PEGs (mean 38.30, SD 22.42).

The first regression model indicated that the time tube fed and perceived level of medical complexity predict time taken to wean. Adding type of tube to the regression, however, created the strongest predictive model of time taken to wean (Table 3).

TABLE 3. Multiple regression model of variables identified in preliminary analyses to have a significant impact on time taken to wean

	Model 0 Univariate analyses n = 62					Model 1 (time tube-fed, medical conditions) n = 62					Model 2 (time tube-fed, medical conditions, type of tube) n = 62				
Variable	*B*	SE	*P*	Exp (*B*)	95% CI for Exp (*B*) Lower/Upper	*B*	SE	*P*	Exp (*B*)	95% CI for Exp (*B*) Lower/Upper	*B*	SE	*P*	Exp (*B*)	95% CI for Exp (*B*) Lower/Upper
Time tube-fed prior	−0.041	0.011	<0.001	0.96	0.94/0.98	−0.039	0.011	<0.001	0.96	0.94/0.98	−0.025	0.011	0.023	0.98	0.96 / 0.99
Medical complexity	0.71	0.29	0.015	2.03	1.15/3.60	0.62	0.3	0.037	1.86	1.04/3.34	0.7	0.31	0.023	2.01	1.1 / 3.67
Type of enteral tube at time of wean	1.47	0.32	<0.001	4.34	2.31/8.17						1.23	0.37	0.001	3.42	1.65 / 7.08
X^2 change from previous step						4.39					11.3				
Significance (*P*) of X^2 change						0.036					0.001				

B = beta value; CI = confidence interval; Exp(B) = odds ratio; P = value of probability; SE = standard error for beta; X^2 = Chi square value.

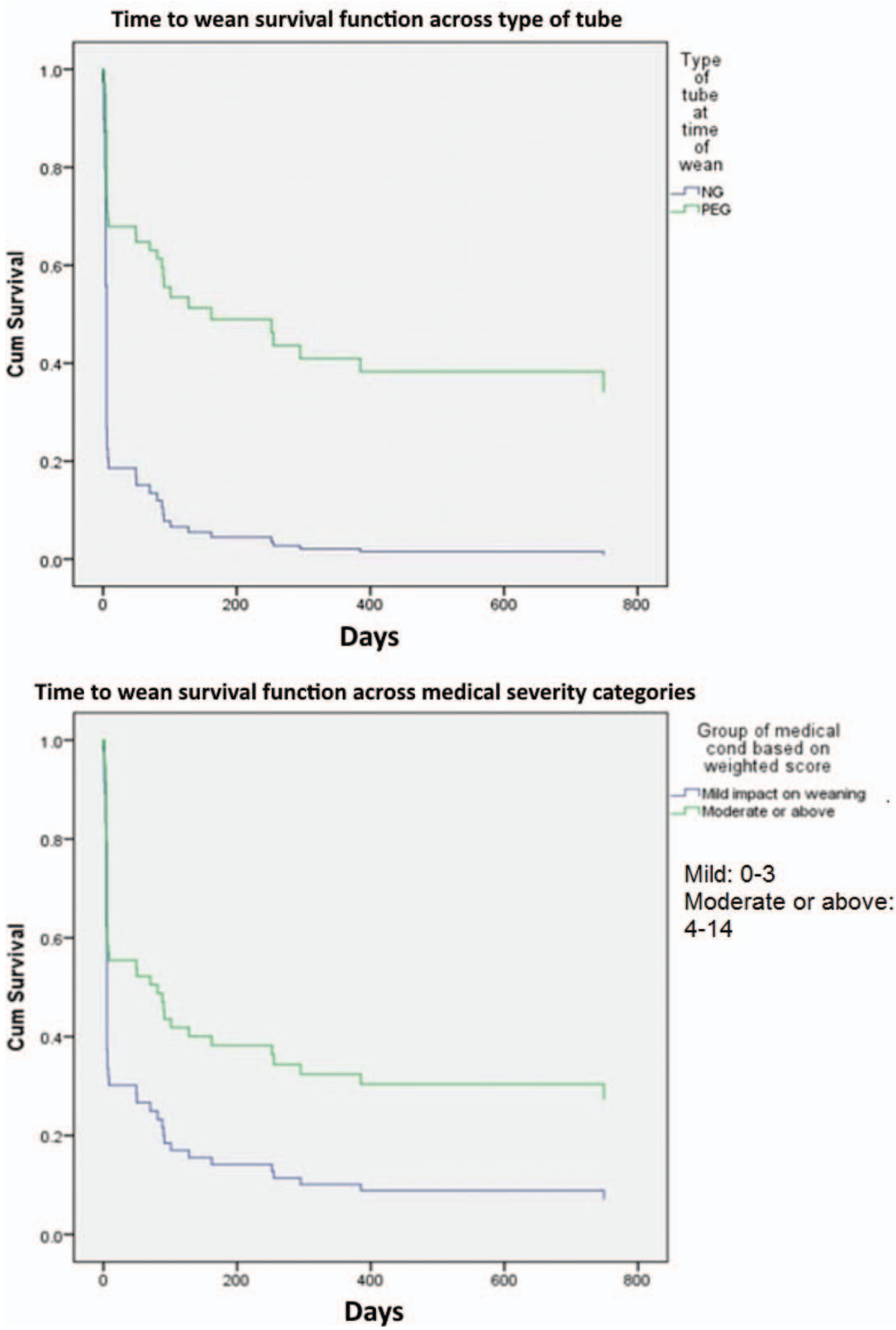

FIGURE 1. Survival analyses showing children with nasogastric tubes (Top panel, solid line) and children deemed medically less complex with regard to weaning (Bottom panel, thicker line) weaned in a shorter time than children with PEG tubes or more medically complex children, respectively. NG = nasogastric; PEG = percutaneous endoscopic gastrostomy.

Finally, survival analyses comparing time taken to wean between NG versus PEG tubes and between the 2 levels of perceived medical complexity revealed shorter weaning times for children with NG tubes ($X^2 = 23.19$, $P < 0.001$) and children who were deemed medically to be less complex ($X^2 = 5.99$, $P = 0.014$) (Fig. 1). Medical complexity, however, did not differ between children who were fed via an NG or a PEG tube ($X^2 = 1.60$, $P = 0.207$).

DISCUSSION

Tube weaning children is a delicate process that is influenced by many individual, social, and psychological variables. A file audit of 62 children weaned through an intensive interdisciplinary, family-centred program showed that biological/physical factors such as the type of feeding tube, complexity of medical conditions, age, and length of time tube fed were all significantly correlated with the time taken to wean. A logistic regression model including the length of time tube fed, type of feeding tube, and degree of medical complexity was, however, the strongest predictor of time taken to wean.

Factors Correlating With Time Taken to Wean

We explored several biological factors generally assumed to be correlated with time taken to wean. For example, a child's age and time tube fed before the weaning period positively correlated with time taken to wean. This suggests that younger children wean more quickly, perhaps because they are less psychologically dependent on the tube having been tube fed for shorter periods of time. We investigated the relationship between a child's degree of medical complexity and time taken to wean because it was anticipated that a more medically fragile child may be more difficult to wean because life-saving treatments took precedence over learning to eat. Those children deemed as medically ''more complex'' did indeed take longer to wean, a finding that remained significant in the strongest predictive model in the regression analysis. We also, however, note that even the children in the more complex group successfully weaned over the course of the intensive weaning program, albeit taking about 9 times as long as the children in the less complex group.

These findings have 2 important implications. First, a higher degree of medical complexity does not prevent children from successfully weaning from tube feeding. Our finding of a longer time taken to wean should not preclude more medically complex children from attempting to wean in a supported environment. Second, parents of more medically complex children may require specifically tailored assistance that enables them to support their child through a longer weaning process.

Children with NG tubes transitioned 3.6 times faster from enteral to oral feeding and had an overall shorter duration of tube feeding before admission than children with PEG tubes. It is likely that the shorter period of reliance on tube feeding contributed to the shorter duration of the weaning process. In addition, it may be that greater oral invasiveness and the more overt visual appearance of the NG tube provided greater motivation to transition faster to oral intake, although this was not formally evaluated in this study. Of note, children with an NG tube were not significantly less likely to have a medical complexity rating of ''moderate-severe.''

Factors Not Correlating With Time Taken to Wean

In preliminary analyses, we explored several variables usually assumed to potentially influence time taken to wean and used by health professionals as indicators for readiness to wean (eg, a child's prior oral experiences or mealtime behaviours). In Australia, parents have anecdotally reported that they have been refused weaning by some teams based on the parameter of not yet eating/drinking ''enough.'' Our analyses demonstrated that a child's oral experiences or the way they engage at mealtimes did not predict the weaning time and therefore these variables alone should not be the basis for deciding whether a child is ready to wean. Similarly, body mass index *z* scores did not predict time taken to wean, suggesting that solely relying on this measure to clinically determine readiness to wean may also be insufficient.

Limitations

We believe the following limitations apply. First, the sample size of 62 children limited some of the analyses that could be conducted, in particular the size of the multiple regression model. For this reason, we conducted preliminary analyses on individual variables to identify those most appropriate to include in the final regression model. We note, however, our sample size compares well with international tube weaning literature in which participant numbers vary from single case studies (26), to 10 (27) and 221 participants (15). In these studies children were medically healthy (ie, nonorganic reasons for tube feeding) or experienced a variety of medical conditions and had been tube fed on average for more than 3/4 of their lifetime. This is comparable with the current study in which 87% presented with comorbid medical conditions and tube feeding for a mean of 2.1 years. We also note that our findings are based on data obtained retrospectively and relate to this specific program only; however, they provide a basis for comparison and consideration by other programs and future research.

Second, although a rigorous process was undertaken to standardize the clinical judgements being made about oral skill, mealtime behaviour, and weaning-related medical complexity, further validation of these ratings scales is warranted and our findings relating to these variables should be interpreted in this context. Those categorized as less medically complex, however, did wean significantly faster than the more medically complex, suggesting clinical classification represented a meaningful grouping.

CONCLUSIONS

This retrospective case audit investigated biological factors thought to influence the time taken for children to transition from enteral feeding to full oral intake. Our analyses suggest that, of the variables presumed to impact on time to weaning, time tube-fed and type of feeding tube combined with degree of medical complexity were the strongest predictors of time taken to wean in this cohort. Variables such as the volume of oral food and drink a child consumes before weaning, ability to chew textured foods, or gain additional weight before weaning were not predictive of time taken to wean. These variables, therefore, should not be the main criteria when deciding to initiate weaning.

The intervention approach audited assumes that weaning success relies on the child and caregiver engaging in a relationship which involves mutual trust and respect of feeding cues and behaviours. Our findings suggest further research should consider investigating whether psychological variables can mitigate the impact of physical variables with a view to developing a biopsychosocial model for tube weaning.

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