WEIGHT LOSS DURING AMBULATORY TUBE WEANING: DON'T PUT THE FEEDS BACK UP

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Short title: predictors of tube weaning duration

Abbreviations.

BMI body mass index, SD standard deviation, SDS standard deviation (Z) score, SF Skinfolds, WFH weight for height, UK United Kingdom WHO World Health organization

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Author contributions

Charlotte Wright: Conceptualization; Data curation; Project administration; Formal analysis; Methodology; Writing original draft; review & editing.

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ABSTRACT

Objective: To describe the prevalence of weight loss during tube weaning and its impact on wean duration and growth.

Setting: Tertiary feeding clinic, UK.

Patients: All children seen for weaning from long term enteral feeding between 2008 – 2016.

Interventions: Outpatient withdrawal of enteral feeding.

Design: Case series of children being weaned from tube feeding, documenting clinical details, periods of weight loss and timing of feed changes, as well as height and weight at baseline and within one year after feed cessation.

Main outcome measures: Amount and frequency of weight loss, wean duration, change in BMI and height SDS.

Results: Weaning was attempted in 58 children, median age 2.7 years and 90% had stopped feeds after median (range) 5.9 (1 – 40) months. Weight loss was seen in 51 (88%) children and was more common and severe in children with initially higher body mass index (BMI). Time to feed cessation reduced by median 4.9 months between 2008-11and in 2012-16, while having feeds increased prolonged the wean duration, by median 13 months. After feed cessation mean (SD) BMI had dropped by 0.85 (1.2) Z scores, but neither change in BMI, nor the amount and frequency of weight loss related to growth.

Conclusions: Short-term weight loss is to be expected during tube weaning and is not associated with compromised growth. It is important to avoid over-feeding enterally fed children and not to increase feeds again in response to weight loss.

BACKGROUND

Enteral feeding is essential for many severely ill neonates and infants, but the transition to oral feeds is not always straightforward. Children who have been enterally fed since early infancy have often missed the usual transitions to complementary feeding, tend to lack feeding skills and may not have experienced hunger, while their parents commonly experience great anxiety around feeding and weight gain (1). A number of programs have been set up to address tube dependence worldwide (2). Most descriptions in the literature are of in-patient programs, with feeds being withdrawn over a matter of days(2). There have been fewer descriptions of slower, out-patient tube weaning programs (3-5), although these will be more feasible in most settings. The clinic described in this paper was set up within a large, National Health service children's hospital in the UK (www.nhsggc.org.uk/rhcfeedingclinic) to provide an out-patient multidisciplinary tube weaning service (6-8). The clinic accepts children who are medically stable and able to swallow safely, based on history and or video fluoroscopy, where the referring team have been unable to withdraw tube feeding (7, 8). Sessions are run jointly by a paediatrician, dietitian, and a psychologist who support parents to gradually reduce feeds, each time by around 10% of total requirements; this then allows children to experience hunger and develop feeding skills. Meanwhile, the team provide dietetic and psychological support for families and a psychology assistant does individual work with some children on feeding skills. Further reductions are only made once any resulting weight loss has ceased, so the extent of weight loss and how it is managed is crucial. We previously described factors predicting successful weaning in the clinic's first five year (6). We have recently found that the great majority of children can be weaned successfully, but that the time to feed withdrawal varies greatly. We thus planned a new retrospective audit of children to describe the prevalence of weight loss during tube weaning and how it relates to wean duration and growth.

Methods

This was a retrospective notes review, not requiring ethical permission. The study period was selected to start immediately after our last survey (6) and finish at a date that would allow the weaning process to have been completed for all included children when the data were collated in 2020. Thus, all new patients accepted by the feeding clinic for tube weaning and seen between January 1st, 2008, to December 31st, 2016, were studied.

Data extraction

The children were identified from the clinic database and their records searched to identify the date feed reduction began and of subsequent appointments and feed changes. At most visits weight, and usually height/length, were measured by trained nursing staff, using digital scales and stadiometers, and recorded on an electronic database. At baseline we retrieved the measured weight and height and then the weight recorded at each subsequent visit until the last visit within one year after feed cessation, where both weight and height were retrieved. We also retrieved basic clinical information and the volume of feeds at baseline from the electronic record.

LMSgrowth (9) was used to calculate weight and height and body mass index (BMI) SDS scores compared to the UK-WHO growth reference(10). The type and volume of feeds just before feed reduction began were used to calculate the total daily energy supplied by feeds. The child's age-appropriate energy requirements per kilogram(11) were then used to calculate Feed Dependency, the percentage of total energy requirements supplied by feeds. The lowest weight recorded after the first feed reduction was used to calculate initial weight change as a percentage of initial weight. The weights at each visit were then examined to identify all periods of weight loss, defined as starting on the last date of measurement before a lower weight and ending when a weight was higher than the starting weight. A semianonymized data set (without names or dates of birth) was then then entered into IBM SPSS v 28 for analysis.

Analysis

The primary outcomes were Wean Duration (months from first feed reduction to when last feed stopped). Secondary outcomes were initial percentage weight loss, number of weight loss periods and change in height and BMI SDS between baseline and follow up.

As the wean duration was markedly skewed, Kruskal Wallace or Mann Whitney U was used to compare median values. When modelling multivariable predictors of wean duration all predictors with $p<0.1$ were placed together in a linear regression model with log duration as outcome and non-significant variables removed until all variables in the model were $p<0.05$. As the number of periods of weight loss were strongly correlated with whether feeds were increased, these variables were added individually to separate models.

RESULTS

Weaning was attempted in 60 children, but one child proved unsuitable, due to severe neurodevelopmental problems and one was lost to follow up. The remaining 58 children (47% girls) had a variety of, often multiple, medical and surgical problems, with 11 (18%) born preterm (table 1). Developmental status was not recorded consistently over the whole period, but 20 (33%) children were recorded as having at least moderate developmental delay or learning disability. Nearly half (44%) were receiving 80% or more of their requirements via tube feeds (Table 2).

After first feed reduction 30 (50%) children showed little or no weight loss, 16 (27%) lost 1-3%, 9 (15%) 5-10% and 3 (5%) more than 10% of their initial weight. Other children lost weight later in the weaning process, with only 7 (12%) never showing any weight loss, while 17 (29%) lost weight 2 – 4 times. Children with higher BMI had more initial weight loss and weight loss episodes (Table 3). There were no significant associations between age, gender, or degree of feed dependence and either the amount or the number of weight loss episodes (data not shown).

After a median (range) of 3 (1-8) feed reductions over 5.9 (1 – 40) months, 52 children (90%) had stopped all feeds. Feeds were increased at least once in 12 (25%) children. These children showed similar characteristics to those whose feeds had not been increased but had average feed duration 12 months longer (table 2). The number of periods of weight loss was strongly associated with wean duration, though not the amount of initial weight loss (Table 2).

There was no difference over time in the amount of feed dependence or in baseline BMI z score or the underlying clinical features, but Wean duration reduced by median 4.9 months between 2008-11 and in 2012-16. Over time the number of feed reductions made before cessation decreased significantly (Median (range) 2008-11 4 (1-8); 2012-16 3 (1-7) P Mann Whitney =0.023) and the proportion (number) of children where the feeds were ever put back up reduced from 38% (8) in 2008-11 to 14% (4) in 2012-16 (P χ^2=0.09).

The number of periods of weight loss was strongly related to whether feeds were ever put back up and this had a multiplicative effect on wean duration (Figure 1, supplementary table1). Children who had 3-4 periods of weight loss, and whose feeds were put up had median wean duration of 27 months compared to 11 months for those who did not. (p<0.001).

In a simultaneous linear regression model, log wean duration was longer for boys (Beta=0.24 P=0.043) and children with developmental delay (Beta=0.26 P=0.034) and shorter in recent years (-0.27 P=0.029), but the strongest predictors (added into separate models because of collinearity) were the number of periods of weight loss (Beta =0.483 P<0.001) and whether feeds were increased (Beta=0.387 P=0.002).

At the last measurement, collected mean (SD) 7.2 (3.4) months after feeds ceased, BMI had dropped 0.85 (1.2) SDS to -1.1 (1.4) SD. Overall height SDS showed a slight decline, but only 6 (12%) children showed a fall greater than 0.7SD. There was no association between initial % weight loss or change in BMI SD and subsequent height gain (Table 3). There was also no association between baseline or change in height or BMI z scores and time to feed cessation (data not shown).

In six children complete feed withdrawal was not achieved and after 4-9 years follow-up all remained at least partially tube fed. They were no different in terms of initial BMI, feed dependency, age, or amount of weight loss from those successfully weaned. Two children, both with learning difficulty, had shown no increase in interest in food after 5 and 7 years. The other four had acquired good feeding skills and reduced tube dependency but continued partial tube feeding due to a combination of medical and social complexity. One other child who had been weaned without weight loss, later lost weight for other clinical reasons and was restarted on feeds.

DISCUSSION

Long-term enteral feeding has substantial social and health care costs, but it is hard to develop expertise in managing tube dependency as it presents relatively rarely in most centres. Our earlier study(6) and a recent larger case series using a similar outpatient feed reduction regime by Di Pasquale (3) showed that children could be safely tube weaned. In this new series we consider the role weight loss plays in how long the process takes.

Most children lost weight at some point, which is in keeping with two earlier case series of rapid weaning (12, 13) although another found no net change in BMI(14). While the wean duration was longer in boys, as found in another study(15), and in children with developmental delay, much the strongest predictors were the number of weight loss periods and whether feeds had been increased (Figure 1). We successfully weaned 90% of children, compared to 70% in DiPasquale's series, where in 11% of wean attempts feeds were restarted because of rapid weight loss (3). The association of weight loss with initially higher BMI has not been reported before, but in another case series children who failed to stop feeds had markedly higher BMI at baseline (+1 SD) compared to those successfully weaned (-0.41)(16). This suggests that some children may need to lose surplus weight before they can develop an interest in food., but there is a risk that high initial weight loss will lead to termination of the weaning process.

A strength of this study is the inclusion of growth outcomes collected well after feeds had stopped. It was reassuring, as in our first series (6) to find no evidence that weight loss led to slowing of growth. Few studies of rapid tube weaning have tracked growth over time, but one found a marked decline in height centile (17) while another did not (15). Our slower approach, which avoids more drastic variation in energy intake seems to successfully protect against growth compromise.

There are several limitations to this study. Like most previous studies it lacks control data. The children studied were necessarily seen for the first time 5 -13 years ago, to allow enough time to track every child to the end of their weaning process. The numbers available gave us only limited power to explore different predictors and to construct multivariable models. We also lacked any objective information on oral skills and feeding behaviour.

Although the case mix of children was unchanged over time, the median duration of feed withdrawal reduced from 9.3 to 4.5 months. We suspect that this reflects increased attention to frequent follow up to keep the weaning process on track, as well as becoming more confident in the management of weight loss. We make fewer, larger reductions, once parents are confident to proceed and we give anticipatory guidance about likely weight loss. Further feed reductions are only made once at least some weight regain has occurred, but the aim is never to put feeds up again unless there has been substantial (>10%) weight loss and no improvement in appetite.

Where possible we involve members of the referring clinical teams to prevent families from receiving conflicting messages. We have now characterised this in our tube weaning protocol (see Figure 2 and www.nhsggc.org.uk/rhcfeedingclinic).

CONCLUSIONS

Some short-term weight loss should be expected during tube weaning and should not be treated as an adverse outcome. It is important to avoid letting enterally fed children become overweight and not to respond to weight loss by increasing feeds, as this greatly prolongs tube dependence.

What is already known on this topic

- Enteral feeding, while life saving for severely ill neonates and infants, can prove difficult to withdraw, leaving children on long term home enteral feeding.
- If there is weight loss when feeds are reduced, this commonly leads to feeds being increased.

What this study adds

- Some short-term weight loss was seen in most children and was greatest in children with higher initial body mass index.
- Weight loss and a decline BMI during tube weaning were not associated with slow subsequent growth
- Increasing feeds again during the weaning process greatly prolonged tube dependance.

. **How this study might affect research, practice or policy**

- Long-term enteral feeding place a substantial burden on families and health providers.
- If clinicians can better manage the weight loss usually associated with tube weaning these costs could be much reduced.

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Transparency Declaration

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

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Table 1: Diagnoses of children undergoing tube weaning (could be on-line)

Problem		
Neurodevelopmental problems[1]	18	30%
Ex preterm	9	15%
Gastro oesophageal reflux	8	13%
Neonatal surgical issues[2]	11	18%
Complex congenital heart disease	7	12%
Renal: cystinosis, diabetes insipidus, haemolytic uraemic syndrome	3	5%
Oncology: leukaemia, osteosarcoma	2	3%
Weight faltering / food refusal	2	3%
Total	60	

[1]4 Developmental delay, 2 Autism spectrum, 2 epilepsy, 1 each of CHARGE syndrome, Costello Syndrome, Spina bifida, Edward syndrome, congenital myopathy, fetal alcohol syndrome, cerebral palsy, congenital zoster, chromosomal abnormality, undiagnosed syndrome,

[2]3 Cleft palate, 2 Short bowel syndrome, 2 Diaphragmatic Hernia, Treacher Collins Syndrome, tracheoesophageal fistula, exomphalos, anal agenesis

Table 2: Time to feed cessation, by amount of initial weight loss, number of periods of weight loss, age, level of feed dependence, developmental delay and date wean started

	Total	Percent	Time to feed cessation[1] months)	P
Age				
<2 yrs	21	40.4	5.06 (0.1-33)	
2-5 yrs	17	32.7	6.91 (1.3-28)	
>5 yrs	14	26.9	6.37 (1.4-49)	0.67[2]
Sex				
Male	27	51.9	8.3 (0.4-49)	
Female	25	48.1	4.6 (0.1-26)	0.01[3]
Feed dependence				
<50%	13	25.5	5.3 (0.06-20)	
50-90%	20	39.2	10.8 (3.7-49)	
>90%	18	34.6	4.3 (0.4-33)	0.08[3]
Year wean started				
2008-11	23	44.2	10.36 (1.4-49)	
2012-16	29	55.8	4.87 (0.1-31)	0.02[3]
Developmental delay noted				
Yes	17	33	9.8 (1.2-49)	
No	35	67	4.9 (0.1-33)	0.05[3]
Amount of initial weight loss				
<1% or gain	28	53.8	5.44 (0.07-49)	
1-5%	15	28.8	6.90 (1.41-31)	
>5%	9	17.3	5.29 (1.25-26)	0.65[3]
Periods of weight loss				
None	7	13.5	1.80 (0.1-12)	
one- two	32	61.5	5.18 (1.3-31)	
Three-four	13	25.0	14.9 (5.1-49)	0.002[2]
Feed volume increased again during weaning period				
Yes	12	24.5	18.0 (8-49)	0<.001[3]
No	37	75.5	4.9 (1-30)	

[1]missing for one child [2]Kruskall Wallis [3]Mann Whitney U

Table 3: Height and body mass index at baseline in all children (N=58) and change to end of tube weaning (n=52) by amount of initial weight loss, number of periods of weight loss, age, level of feed dependence and date wean started (could be on-line)

			Baseline		Change to last follow up	
	Total		**Height SDS[1]**	**BMI SDS**	**Height SDS[2]**	**BMI SDS[3]**
All children			Mean (SD)	**Mean (SD)**	Mean (SD)	Mean (SD)
	Number	%	-1.51 (1.2)	**-0.18 (1.3)**	-0.11 (0.84)	-0.85 (1.2)
Amount of initial weight loss						
<1% or gain	30	52	-1.35 (1.1)	**-0.61 (1.3)**	1.42 (0.7)	**-0.55 (1.2)**
1-5%	16	28	-1.27 (0.9)	**-0.06 (1.2)**	-0.71 (0.5)	**-1.00 (1.1)**
>5%	11	21	-2.25 (1.4)	**0.79 (0.9)**	0.17 (1.1)	**-1.49 (1.1)**
P[5]			0.08	**0.002**	0.27	**0.037**
Periods of weight loss						
None	7	12	**-2.31 (1.0)**	**-1.19 (1.1)**	0.27 (0.82)	-0.57 (1.8)
one- two	35	61	**-1.53 (1.2)**	**-0.29 (1.1)**	-0.04 (0.83)	-0.87 (1.1)
Three-four	15	26	**-0.97 (0.8)**	**0.53 (1.4)**	-0.49 (0.75)	-0.90 (1.2)
P[5]			**0.01**	**<0.001**	0.051	0.67
Age						
<2 yrs	23	40	-1.76 (1.3)	-0.63 (1.2)	0.05 (0.88)	-0.98 (1.3)
2-5 yrs	19	33	-1.28 (1.0)	0.26 (1.7)	-0.40 (0.84)	-0.87 (1.0)
>5 yrs	16	28	-1.40 (1.1)	-0.15 (0.6)	-0.01 (0.70)	-0.61 (1.2)
P[5]			0.30	0.17	0.69	0.40
Feed dependence						
<50%	15	27	**-1.15 (1.2)**	0.21 (1.3)	-0.16 (0.6)	-1.30 (1.0)
50-90%	23	41	**-1.38 (1.1)**	-0.16 (1.2)	-0.19 (0.9)	-0.85 (1.2)
>90%	18	32	**-2.00 (1.0)**	-0.47 (1.2)	0.025 (0.9)	-0.55 (1.2)
P			**0.033**	0.13	0.54	0.11
Year wean started						
2008-11	24	41	-1.50 (1.0)	-0.33 (1.5)	-0.22 (0.77)	-0.96 (1.3)
2012-16	34	59	-1.52 (1.3)	-0.13 (1.1)	-0.03 (0.89)	-0.74 (1.1)
P[6]			0.95	0.56	0.43	0.53

[1]missing for 3 children [2]missing for 10 children [3]missing for 11 children [5]ANOVA trend [6]ANOVA

Figure 1: Box plot of association between number of weight loss episodes, feed increases and wean duration. The authors can confirm that we have permission to reuse the image which was created by Charlotte Wright

Figure 1

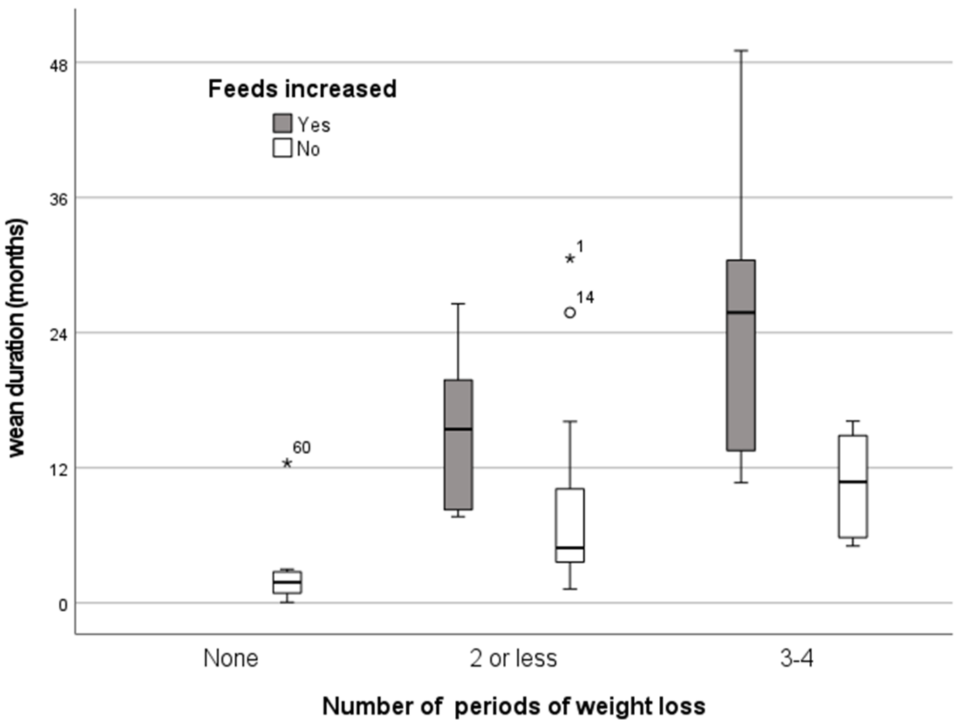

Figure 2: Protocol used for tube weaning a/ after feed reduction by 15-20% of total requirements b/ one month after weight loss; For further details see www.nhsggc.org.uk/rhcfeedingclinic The authors can confirm that we have permission to reuse the image which was created by Charlotte Wright

Figure 2