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Original article

Intermittent bolus versus continuous feeding in children receiving an enteral formula with food derived ingredients: A national multicentre retrospective study

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ABSTRACT

Background and aim: A perceived factor believed to have an impact on feed tolerance relates to the mode in which nutrition is delivered regarding intermittent bolus or continuous feeding. Enteral formulas with food derived ingredients have been developed to help address some of the many feeding issues experienced by children who are tube fed. This study aimed to evaluate the tolerance of different feeding modes in children who are fed with an enteral formula with food derived ingredients.

Methods: Data was collected by paediatric dietitians from dietetic records over a month period on children who had switched to an enteral formula with food derived ingredients. Data was inputted to a Microsoft form to capture the impact of varying modes of feeding (intermittent bolus/continuous/combination) on gastrointestinal and anthropometric outcomes.

Results: Forty-three children were recruited between March 2021 to July 2021 across four National Health Service Trusts. Children who were continuously fed saw the greatest reported improvement in retching, abdominal pain and loose stools. Children who were fed intermittent bolus reported the greatest increase in weight (p-value 0.003). Over 90% of dietitians reported nutritional goals were achieved after switching formula; children who were fed continuously reported the highest achievement to meet dietitian's nutritional goals.

Conclusion: Enteral formulas with food derived ingredients are well tolerated and effective in achieving weight gain and meeting dietetic goals whether delivered continuously or as intermittent bolus feed. The clinical situation will determine the most appropriate and effective feeding mode and should be guided by the dietitian and medical team.

1. Introduction

Enteral nutrition is the preferred route for the nutritional support of patients who are unable to meet their nutritional requirements orally [1]. Standard enteral formulas are easily quantifiable, convenient, portable, safe and reasonably cost effective [2]. Clinical manifestations of enteral feeding intolerances, such as abdominal distension, bloating, and nausea, are some of the complications that can occur in patients. The frequency of diarrhoea in enteral fed patients ranges from 29% to 72% [3,4]. The management of persistent feed intolerances results in repeated feed withdrawal, contributing to malnutrition through reduction in nutritional intake, decrease in absorption of nutrients, and increase in catabolism of nutrient reserves [5].

Another perceived factor believed to have an impact on feed tolerance relates to the mode in which nutrition is delivered in relation to intermittent bolus or continuous enteral feeding. This ongoing debate regarding the most effective mode of feeding has been listed in both the adult [6] and paediatric intensive care nutrition research priorities [7]. Intermittent bolus feeding is administered multiple times per day (generally 4–6 times/day) over a period of 20–60 min/time [8]. The terms intermittent and bolus feeding are usually used interchangeably in studies [9].

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Whereas, continuous feeding is delivered at a lower infusion rate over a longer time period and commonly adopted in acute clinical settings as its theoretically better tolerated [9].

In infants, previous studies have demonstrated the beneficial impact of both intermittent bolus and continuous feeding; continuous feeding is associated with energy efficiency, duodenal motor function, optimal nutrient absorption, and splanchnic oxygenation. However, intermittent bolus feeding has been associated as a more physiological release pattern of gastrointestinal tract hormones, stimulates gastrointestinal tract development, and enhances protein accretion [10,11].

Additionally, intermittent bolus feeding provides increased flexibility for parents or carers and more suited for children who are mobile and want less time connected to a feeding pump. A study conducted in the United Kingdom saw an increase in the use of bolus feeding across 'Home Enterally Tube Fed' (HETF) patients. The study found patients used intermittent bolus feeding as their sole feeding method (46%), as a top-up to oral diet, or to mimic mealtimes, due to this method being quick and easy to use [12].

In the paediatric population interest is growing in the use of a blended diet for the management of feeding intolerances [13]. Blended diets are food-based formulas liquified to a consistency that will enable passage through a feeding tube. It is perceived to be more natural and better tolerated compared to commercially available enteral formulas [14]. Previous studies have reported positive clinical outcomes with the use of blended diets, including reduced gagging, retching, and vomiting compared to commercially available enteral formulas [15,16].

The mechanisms as to why a blended diet is better tolerated than a standard enteral formula is unclear [16]. However, it stands to reason "real food" aids normal gut functioning. Furthermore, there is evidence to suggest fibre within blended diet stimulates the growth of beneficial gut flora bacteria, thereby inhibiting harmful bacteria [17]. Industry have responded to this cultural shift in adopting "real food" blended diets and developed enteral tube feed that contain rehydrated food, accounting for 1 g Fibre (100 ml). These formulas were designed in the hope to address the feeding issues children experience and to be an alternative or used in combination with blended diets in an acute clinical setting when a blended diet may not be possible [18].

This study aimed to evaluate the tolerance of different feeding modes (intermittent bolus/continuous/combination) in children who are fed with an enteral formula with food derived ingredients.

2. Materials and methods

2.1. Patients

This retrospective, multi-centre chart review gained ethical approval from the Health Research Authority and Health and Care Research Wales (HCRW) 20/HRA/4828. The study was conducted during March 2021 to July 2021 across four National Health Service (NHS) Trusts around England; three of which were tertiary paediatric hospitals and one was a community based setting.

Data was collected by paediatric dietitians from medical and dietetic records and inputted to a Microsoft form to capture anthropometric and gastrointestinal outcomes over a month period when children were switched to an Enteral Formula with food derived ingredients. The nutritional composition of Compleat® paediatric is outlined in Table 1. Compleat® paediatric is a nutritional complete commercially manufactured enteral formula that contains 13.8% food derived ingredients from rehydrated chicken, rehydrated vegetables (peas & green beans), peach puree and orange juice from concentrate. A link to the Microsoft forms was sent to each site by the Clinical Research Company (CRC) Ixia Clinical Ltd.

Table 1
Nutritional composition of Compleat® paediatric - an enteral formula with food derived ingredients.

Nutritional profile	Per 100 ml
Energy, kcals	117
Fat, g	5
Carbohydrate, g	14
Fibre, g	1
Protein, g	3.6
Osmolarity, mOsm/l	280

Once the Microsoft forms were completed by the dietitian forms were automatically sent to Ixia Clinical Ltd. Sub analysis data on different feeding modes intermittent bolus, continuous and combination were analysed by an independent statistician.

Children were included if they had switched to the new enteral formula for at least one month and accounted for at least 80% of their total energy requirements. All eligible children were aged between 1 and 17 years old. The feeding mode and feeding regimen remained the same after switch to new formula. Retrospective data specifically focused on any changes related to feed tolerance including gagging and retching, vomiting, gas, flatulence, and stool consistency. Data was also collected to capture any changes before and after switch to the new enteral formula in relation to feed volume, calorie intake and medication related to stool frequency and consistency. This data can be found in our first publication crossref DOI link: https://doi.org/10.1002/NCP.10812. In this publication we will focus on mode of feeding (intermittent bolus, continuous and combination) in relation in dietetic outcomes, weight and gastrointestinal symptom management.

2.2. Statistical analysis

The primary outcome of interest was feed tolerance – for each measurement period, the change in feed tolerance was assessed for each patient to identify any trends. Sub analysis data on feeding modes intermittent bolus, continuous and combination were analysed. Measurements were recorded as median and interquartile range (IQR) for weight (kg) and height (cm). Z scores of weight-for-age and height-for-age were computed based on UK-WHO growth data [19,20]. To examine the changes in weight (kg) in relation to feeding mode, a paired t-test was used to produce a P-value and confidence interval. A P-value <0.05 was deemed statistically significant. Statistical analysis was performed with SPSS software (version 23; IBM SPSS Statistics, Armonk, NY, USA).

3. Results

Forty-three children were included in this national multicentre, retrospective study. Demographic, primary medical diagnosis, anthropometric, and feeding history data are provided in Table 2. The median age of children who had switched to an "enteral formula with food-derived ingredients" was 6 years old (IQR, 4–8). The most frequently recorded primary diagnosis of children who had switched to the new enteral formula was related to neurological or neuro-disability 20 of 43 children (47%). The median time children received an enteral formula before switching to the new enteral formula was 52 weeks: (IQR, 24–120).

Over half of the children in this retrospective chart review were on intermittent bolus feeding and 81% (35 of 43 children) were on a gastrostomy feeding tube. Five (11%) children were fed in to the jejunum, of which two (8%) children were fed as boluses over 2-h at each feeding episode (Table 2).The median feed volume of children receiving intermittent boluses was 150 ml (IQR 75 ml–190ml); 4

Table 2
The demographic characteristics in relation to feeding mode of children who had switched to enteral formula with food derived ingredients.

Characteristic	All	Intermittent bolus	Continuous pump	Combination bolus/continuous
Total	43 (100%)	24 (56%)	15 (35%)	4 (9%)
Gender, n (%)				
Female	15 (35%)	7 (23%)	6 (40%)	2 (50%)
Male	28 (65%)	17 (70%)	9 (60%)	2 (50%)
Age, median (IQR), years	6 (4–11)	6 (3–9)	6 (4–11)	9 (6–12)
Weight, median (IQR), kg	19.9 (13.5–26)	20.2 (13.6–26.1)	17.8 (13–25)	21.6 (16.5–25.3)
Weight for Age, Z score	0.6 (0.9)	0.4 (0.9)	0.3 (0.8)	0.8 (0.7)
Height, median (IQR), cm	100 (91–119)	99.1 (90.7–118.2)	100.2 (91.7–116.5)	119.5 (99.1–135.5)
Height Z score (SD)	−0.8 (0.8)	−0.9 (0.7)	−0.4 (0.9)	−1.1 (0.6)
Race, n (%)				
White or White British	32 (74.42%)	18 (75%)	12 (80%)	2 (50%)
Asian or Asian British	6 (14%)	2 (8%)	2 (13%)	2 (50%)
Black or Black British African	4 (9%)	3 (12%)	1 (7%)	(0%)
Mixed Race Black/White	1 (2%)	1 (4%)	(0%)	(0%)
Principal Diagnosis, n (%)				
Neurological/neuro-disability	20 (46%)	12 (50%)	5 (33%)	3 (75%)
Genetic syndrome	10 (23%)	4 (17%)	6 (40%)	(0)
Disordered eating	4 (9%)	2 (8%)	2 (13%)	(0)
Ear, nose and throat complication	3 (7%)	1 (4%)	2 (13%)	(0)
Haematology/oncology	3 (7%)	3 (12%)	(0)	(0)
Renal disease	1 (2%)	1 (4%)	(0)	(0)
Sepsis	1 (2%)	(0)	(0)	1 (25%)
Respiratory disease	1 (2%)	1 (4%)	(0)	(0)
Weeks on formula before switch, median (IQR)	56 (37–124)	52 (34–74)	92 (52–143.1)	120 (98–232)
Feeding Route, n (%)				
Gastrostomy	35 (81.4%)	19 (79.17%)	12 (80%)	4 (100%)
Gastrostomy with jejunal extension	5 (11%)	2 (8.33%)	3 (20%)	(0%)
Nasogastric tube	2 (5%)	2 (8.33%)	(0%)	(0%)
Parental Nutrition	1 (2.33%)	1 (4.17%)	(0%)	(0%)

Abbreviations: IQR, interquartile range.

(IQR 3–6) boluses day. Children with a neurological condition consisted of 50% of the population. There was no significant difference between bolus and continuous feeding when compared with age or ethnicity. However, there was a significant difference with children on bolus feeding when compared with weight (Table 2).

Vomiting was the most common reported feed intolerance prior to children switching to new formula. Children who were continuously feed saw the greatest improvement in vomiting symptoms post feed switch (100%). Similarly, children who were continuously fed saw 100% improvement in retching, abdominal pain and loose stools (Table 3). Children who were fed intermittent bolus or continuous saw equal improvements in constipation symptoms after feed switch.

Children who were fed intermittent bolus reported the greatest increase in weight which was statistically significant (p-value 0.003). Children who were fed continuously or a combination also saw clinically significant weight gain over the one-month period data was collected (Table 4). There was no significant difference in feed volume (ml) ($p > 0.5$), total fluid (ml/kg) ($p > 0.6$) or total daily calorie intake ($p > 0.7$) after switching formulas or within different types of feeding modes (Table 5).

Table 3
Reported change in gastrointestinal symptoms after switching to an enteral formula with food ingredients in relation to mode of feeding.

Gastrointestinal Symptom	Reported % of improvement in symptoms after switch	Intermittent bolus	Continuous	Combination, intermittent
Vomiting	12 (91.67%)	7 (85.71%)	3 (100%)	2 (100%)
Retching	20 (85%)	11 (72.73%)	7 (100%)	2 (100%)
Abdominal Pain	6 (83.33%)	3 (66.67%)	2 (100%)	1 (100%)
Loose stool	11 (90.91%)	6 (83.33%)	5 (100%)	0 (0%)
Constipation	13 (69.23%)	8 (75%)	4 (75%)	1 (0%)

Over 90% of dietitians reported nutritional goals were met after formula was changed. Children who were feeding continuously reported the highest achievement to meet dietitians' nutritional goals (Table 6). The main reason parents chose to switch to a new formula with food derived ingredients was either due to their child previously on a blended diet or were unable to start a blended diet in the clinical setting and felt this formula was an appropriate compromise. The second most common reason for switching formula was due to poor feed tolerance to previous formula. Of these children, those who were intermittent bolus fed had the greatest reported achievements to meet dietetic goals (Table 6).

4. Discussion

Our national multicentre retrospective study of children who had switched to an "enteral formula with food-derived ingredients" reported a significant improvement in gastrointestinal symptoms in both the intermittent bolus and continuous modes of feeding. However, children who were continuously fed reported the greatest improvements in feed tolerance symptoms. Conversely, children who were bolus fed reported the greatest weight gain.

A fundamental issue to any study that is reporting feeding intolerance is that there is no uniform definition. A standardized definition is needed for both clinical and research purposes to

Table 4
Comparison of weight before and after switching to an enteral formula with real-food ingredients in relation to mode of feeding.

Weight, mean (SD), kg	Before Switch	After Switch	Paired Difference	P-value (95% CI)
Gravity bolus	17.0 (10)	20.1 (9)	3.5 (6)	0.003 (1.73–7.68)
Continuous pump	17.1 (9)	19.7 (10)	3.0 (5)	0.052 (−0.03–6.16)
Combination, intermittent	17 (9)	19.22 (7)	3.2 (2)	0.068 (−0.45–6.93)

Table 5
Comparison of total energy, feed and fluid volume before and after switching from a standard formula to an enteral formula with real food ingredients.

	Before formula switch	One month after formula switch	p-value (95% Confidence interval)
Feed volume, ml, mean (SD)	835 (383)	805 (376)	0.49 (−55, 113)
Total fluid Volume, ml/kg, mean (sd)	42 (10)	40 (10)	0.6 (−43, 80)
Feed Calorie, kcal/day, mean (SD)	977 (497)	961 (462)	0.74 (−81, 113)

Abbreviation: SD, standard deviation.

determine the consequences of feeding intolerance in relation to short-term and long-term outcomes [21]. A common default strategy of clinicians to manage perceived feeding intolerance is to transition to a slower rate over a longer period - continuous feeding. Furthermore, there are no pediatric data on the effects of tube-feeding regimens (continuous, bolus, or combination) on hunger, oral skills, or overall health [22].

In a retrospective chart review by Mahoney et al. analysed 24-h multichannel intraluminal impedance in 18 children gastrostomy fed who were experiencing reflux -all children were receiving exclusive enteral nutrition with a combination of daytime intermittent bolus and overnight continuous feedings. Mahoney et al. reported no significant differences in the rate of reflux (reflux events per hour) between no feeding, bolus feeding and continuous feeding periods overall or stratified by prior fundoplication's ($p > 0.40$). After adjusting for age, BMI, feeding rate and feeding volume in multivariate analysis, there were no significant differences in the risk of reflux between different feeding periods. These results suggest that continuous feedings may not offer a significant advantage in reducing reflux burden [23].

Hospital feeding protocols will often dictate the preferred mode of feeding (intermittent bolus or continuous), which often reflects the clinical setting and age of the child [24]. A meta-analysis by Ye et al. (2020) aimed to analyse the evidence comparing the benefits and risks of continuous versus intermittent feeding in low-birth-weight infants. Eight trials were included in the analysis consisting of 728 infants. The authors reported that continuous feeding was superior to intermittent bolus feeding in low-birth-weight infants in terms of weight gain. However, continuous feeding was also associated with increased nil by mouth duration, increased bilirubin, increased non-invasive support, and increased gastric residuals. Continuous feeding thus confers advantages in terms of weight gain, but also has disadvantages compared with bolus feeding [25].

Table 6
Summary of reason why new formula was started and to what extent it met dietitians' goals in relation to mode of feeding.

	Total N=43	Intermittent bolus feeding N=24	Continuous feeding N=15	Combination of bolus and continuous N=4
Dietetic Goals Met				
Greatly achieved	22 (51%)	10 (42%)	10 (67%)	2 (50%)
Achieved	13 (30%)	9 (37%)	4 (27%)	(0%)
Somewhat achieved	7 (16%)	4 (17%)	1 (7%)	2 (50%)
Did not achieve	1 (2%)	1 (4%)	(0%)	(0%)
Reason to Switch formula				
Parent choice for blended diet	21 (49%)	13 (54%)	6 (40%)	2 (50%)
Poor tolerance to previous formula	14 (32%)	7 (29%)	5 (33%)	2 (50%)
Insufficient nutritional intake	3 (7%)	3 (12.5%)	(0%)	(0%)
Improve gastrointestinal symptom	2 (5%)	0 (0%)	2 (13%)	(0%)
Simplify feeding regimen	1 (2%)	0 (0%)	1 (7%)	(0%)
Transition off parental nutrition	1 (2%)	1 (4%)	(0%)	(0%)
Continuing formula after trial	1 (2%)	(0%)	1 (7%)	(0%)

An evidence-based review performed by Littler and Tume (2022) assessed whether bolus or continuous enteral feeding is superior in critically ill children. The review suggested that bolus feeding may be superior in medical children on intensive care to achieve their energy and protein goals faster. However, the authors highlight that current evidence is not strong enough to recommend one feeding method over another and therefore the clinical significance of the results is questionable and further research is needed to identify whether one method of feeding can impact on patient outcomes [21].

A meta-analysis of randomized controlled trials by Ma et al. (2021) to assess intermittent bolus versus continuous enteral nutrition on feeding intolerance in critically ill adults included fourteen trials with 1025 critically ill adults found that intermittent bolus feeding could significantly increase the occurrence of feeding intolerance (risk ratio = 1.64, 95% confidence interval = 1.23 to 2.18, $P < 0.001$). Continuous feeding was associated with lower overall incidence of feeding intolerance, especially in high gastric volume and aspiration. However, decreased constipation incidence and more calorie intake were observed in intermittent feeding group. Because quality of the synthesized evidence was “low”or “very low”, there is considerable uncertainty about this estimate [26].

In our study children with neurological/neuro-disability and genetic disabilities accounted for 70% of all recruits of which 66% were fed successfully via intermittent bolus gastrotomy feeding. However, a Cochrane review performed by Gantasala et al. (2013) to assess the effects of nutritional supplementation given via gastrostomy to children with feeding difficulties due to neuro-disabilities (cerebral palsy) concluded that there was considerable uncertainty about the benefits of a gastrostomy and what the most effective feeding mode for children with cerebral palsy is. Suggesting a well-designed randomised controlled trial is needed to resolve the current uncertainties about the most effective nutritional management for children with neuro-disabilities [27].

The limitations of this study include its small sample size (therefore, results are ungeneralizable to gender and ethnic groups), short trial period, and retrospective design. Rather than stating causation, we can only allude to a potential association of an “enteral formula with food-derived ingredients” and improved gastrointestinal symptoms, specifically related to mode of feeding (continuous versus bolus). However, a strength of the study was its national, multicentre design and that data gathering was from a range of dietitians from different specialties and clinical settings.

5. Conclusions

Our retrospective study demonstrates that an enteral formula with food derived ingredients is well tolerated whether delivered continuously or as a bolus feed in achieving feed tolerance, weight gain and dietetic goals. The clinical situation will determine the most appropriate and effective feeding route and should be guided by the dietitian and medical team. However, the clinical significance of our results requires further research to identify whether one method of feeding is superior in respect to patient outcomes.

Declaration of competing interest

The lead author G O'Connor certifies no affiliations with or involvement in any organization or entity with any financial interest

other than that declared in funding section. Sharan Saduera is a medical affairs dietitian and is employed by Nestlé Health Science.

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