

Research Article

Evaluation of a Nutrition Feeding Algorithm for Children and Adolescents Undergoing Haematopoietic Stem Cell Transplantation (HSCT)

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Keywords

• Nutrition, Feeding algorithm, Children and adolescents, Haematopoietic stem cell transplantation, Enteral nutrition, Parenteral nutrition, Hydrolysed formula

Abstract

Background: Nutrition support during the acute phase post allogeneic haematopoietic stem cell transplantation (HSCT) is required to optimise short- and long-term outcomes for children. An algorithm was developed and evaluated to assist clinicians to make objective and consistent enteral feeding decisions.

Methods: The algorithm was evaluated on all patients who underwent allogeneic HSCT treatment between November 2017 - February 2019.

Results: Of the 48 patients, 43 had a nasogastric tube (NGT) inserted, of which 36 patients received a hydrolysed peptide-based formula, 5 patients received a whole protein formula only and 2 patients were fed an amino acid-based formula. Parenteral nutrition (PN) was used in 41 of the patients. Eleven did not have an NGT in-situ at the commencement of HSCT. Of the remaining 37 patients, 26 followed the algorithm and 11 patients did not comply. The group of patients who did not follow the algorithm had the longest median length of stay (LOS) of 72 days. Patients receiving only EN had the lowest median LOS of 39 days. The two groups that reported better weight outcomes were those who followed the algorithm and those who were fully EN fed.

Conclusions: Effective use of the HSCT feeding algorithm indicated improved patient outcomes for children undergoing HSCT, with better weight outcomes and reduced LOS. Recommendations to improve the efficacy and compliance of the algorithm include regular education/input to the oncology medical teams to better understand objective thresholds for EN and PN commencement.

INTRODUCTION

Allogeneic haematopoietic stem cell transplantation (HSCT) following myeloablative conditioning is a toxic procedure requiring intensive nutrition support. Oral intake during the acute post-HSCT period is decreased due to vomiting, anorexia, mucositis, and diarrhoea. As a result, children who undergo this procedure are high risk for malnutrition [1]. Malnutrition has been associated with increased risk of infection, transplant related mortality and relapse risk [2,3].

Nutrition support is required during the acute phase post HSCT to optimise both short and long term outcomes for children [4], however, despite this being well recognised, strategies to address children's nutritional needs are inconsistent.

To date, parenteral nutrition (PN) has been considered the method of choice for nutritional support for patients undergoing allogeneic HSCT [3,5-7]. However, PN-related complications including metabolic/hepatic disorders, CVC issues, sepsis and gut mucosal atrophy remain common, with complication risk shown to increase with longer duration of PN [8].

Enteral nutrition (EN) has been proposed as the first recommended feeding method post HSCT if the gastrointestinal (GI) tract is functional. This helps to maintain intestinal function and integrity, reduces potential translocation and is associated with minimal complications [2,5,9]. EN has been shown to be safe and effective for feeding patients post HSCT [10,11]. EN is associated with reduced complication rates, improved survival, less acute graft versus host disease (GVHD), faster neutrophil recovery and reduced hospital length of stay (LOS) [2,5]. Financial benefits are also documented [6] [11]. The choice of formula for enteral provision varies. Many studies report use of polymeric formula throughout HSCT [4,14,15], while other reports examining intolerances in severe GI disorders such as intestinal failure suggest extensively hydrolysed formula is better tolerated [16].

Tube feeding tolerance for patients secondary to GI toxicities is a significant concern [12] with challenges for clinicians including the timing of EN initiation, formula choice, and rate of grading. These decisions are mostly dependent on the severity of the gastrointestinal (GI) toxicity and clinician experience. Standardised scales such as the World Health Organization's

Gastrointestinal Toxicity Scale and Common Terminology Criteria for Adverse Events Scales have been developed to classify the severity of GI toxicities to allow for consistent classification of symptoms. Adverse events such as anorexia, vomiting, diarrhoea and mucositis are graded from 1-4 [13].

Children undergoing HSCT often have significant GI toxicity with grades of 3/4 mucositis and diarrhoea for prolonged periods. In the absence of clear evidence in HSCT and when significant GI toxicities are expected, we hypothesise that the most likely tolerated feed would be an extensively hydrolysed formula that provides a hydrolysed protein source together with a proportion of medium chain triglycerides (MCT) and a glucose polymer. Hydrolysed proteins that require less time for digestion and absorption are suggested due the decreased transit time associated with gastrointestinal (GI) toxicity [16]. As residual lactase and sucrase levels are often compromised and lead to carbohydrate malabsorption and osmotic diarrhoea, glucose polymers may be better tolerated, as they require only gluco-amylases for digestion. A high portion of the fat source as MCT may be better tolerated as does not require bile-acids for digestion and may be better absorbed and tolerated where significant GI toxicities are evident. Amino acid base formulas should only be used sparingly due to their higher osmolality which may contribute to osmotic diarrhoea. Free amino acids are less likely to promote gastrointestinal recovery [17].

A feeding algorithm for children undergoing HSCT was developed at the Royal Children’s Hospital (RCH), Melbourne, to assist clinicians to make objective decisions on timing of enteral feed initiation, appropriate formula choice and plan for grading up feeds based on objective measures. The algorithm uses

standardised gastrointestinal toxicity scales to allow for uniform classification of symptoms to help make consistent objective decisions around appropriate use of enteral feeds and PN during the acute HSCT phase.

The aim of this project was to evaluate the clinical efficacy of the algorithm in different oncology patient groups and diagnoses and its resultant impact on patient clinical outcomes including the effective use of a peptide based enteral feed to optimise enteral nutrition (EN) opportunities during this acute stage of HSCT. Barriers to the HSCT feeding algorithm implementation were also to be identified and documented.

MATERIAL AND METHODS

Study design and participants

The HSCT feeding algorithm (Figure 1 and Table 1) has been implemented since November 2017 to guide nutrition support decision making for all children undergoing allogeneic HSCT at RCH. All patients aged 0-18 years who underwent allogeneic HSCT treatment at the RCH were recruited to this prospective study between November 2017 - February 2019. Day 0 (D0) was defined as the day of the stem cell return. Patients were excluded if they died prior to day 30 (D30) post HSCT. Patients with an uncomplicated pre-transplant course were hospitalized 7 to 10 days before transplant whereas children requiring inpatient nutritional rehabilitation or presenting with other medical complications were admitted earlier. Pre-transplant conditioning therapy differed according to disease type and patients’ characteristics and was administered 7 to 10 days before transplant. The medical team/staff working within the HSCT

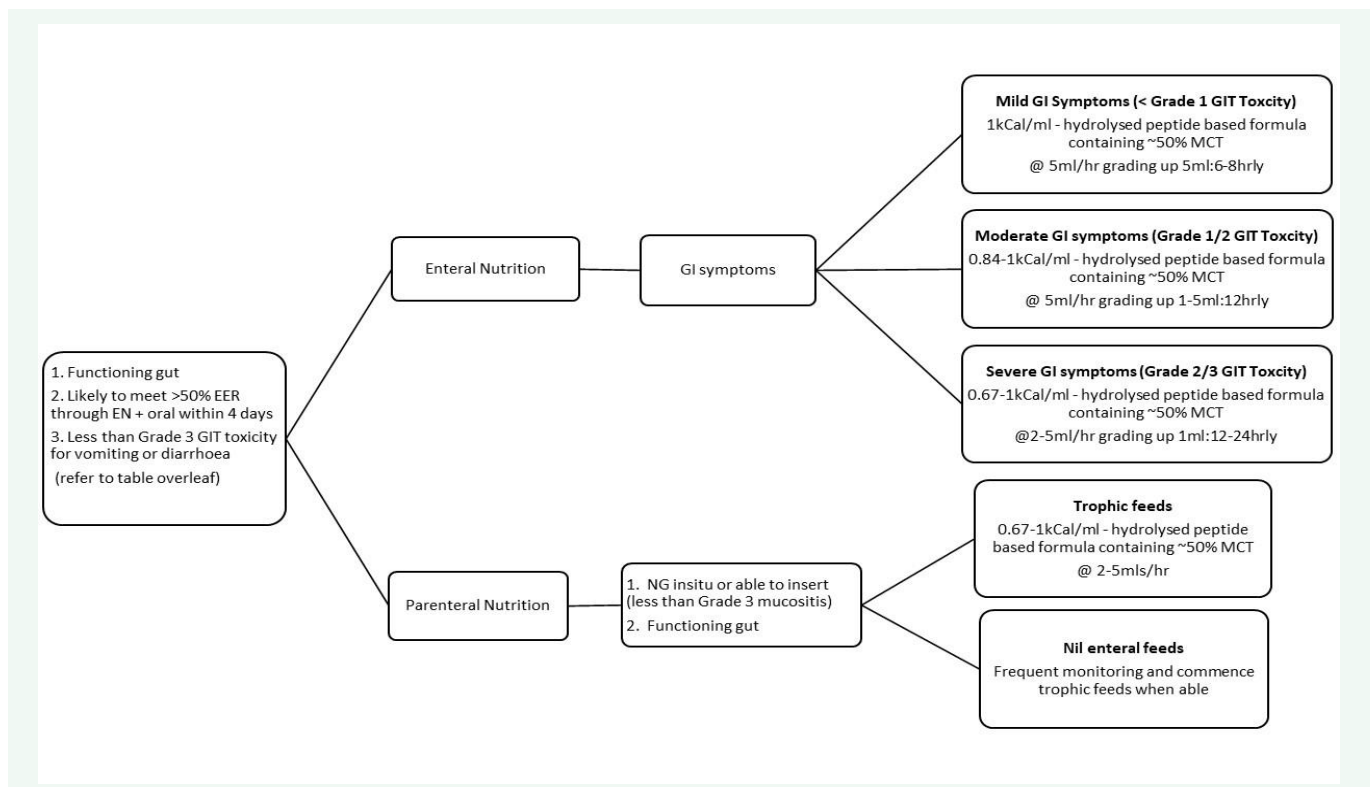


Figure 1 HSCT Feeding Algorithm.

Table 1: World Health Organization's Gastrointestinal Toxicity Scale and Common Terminology Criteria for Adverse Events Scale [13].

Adverse event	Grade I	Grade II	Grade III	Grade IV
Anorexia	Loss of appetite	Oral intake significantly decreased	Requiring IV fluids	requires enteral / parenteral support
Vomiting	1 : 24hrs	2-5 : 24hrs	>6 episodes over 24 hours	Requiring parenteral nutrition support or physiologic consequences requiring intensive care; haemodynamic collapse
Diarrhoea	5-10mls/kg/d <4 stools / day	10-15ml/kg/d 4-6 stools / day	>15m/kg/d >7 stools / day	physiologic consequences requiring intensive care; haemodynamic collapse
Oral mucositis	Painless ulcers, erythema or mild soreness in the absence of lesions	Painful erythema, oedema, or ulcers, but can eat or swallow	Painful erythema, oedema, or ulcers, preventing swallowing or requiring hydration or enteral / parenteral support	Severe ulceration or requires enteral / parenteral support or prophylactic intubation (or documented aspiration pneumonia)

unit were provided education regarding the feeding algorithm decision pathway from the unit dietician. Standard nutritional practice for HSCT patients at RCH (Figure 2), remained consistent over this time period, with the addition of the HSCT feeding algorithm to guide recommendations for use of EN and PN based on objective clinical symptoms.

Data was collected from the RCH electronic medical record for all patients from Day 0 (D0) up to Day 100 (D100). Data included clinical diagnosis, transplant type, EN/PN use and anthropometric data. Weight, height, and weight-for-length (< 2 years of age) or body mass index (BMI) (\geq 2 years of age) were recorded. The results were plotted on World Health Organization (WHO) growth charts for children < 2 years of age and on Centre for Disease Control (CDC) growth charts for children \geq 2 years of age and the associated z-scores were calculated. Complications while on EN/PN was documented but not specifically reported on due to the many confounding factors in interpreting these. Compliance with the HSCT feeding algorithm decision pathway was also recorded and barriers to its use identified. Data was collected until each patient was discharged from their acute HSCT admission and then again at D100.

Nutritional support

As part of standard practice, oral intake was encouraged if tolerated using a low bacterial 'clean diet' from HSCT admission date or on commencement of conditioning therapy. EN was started when a nasogastric tube (NGT) was inserted electively on D-1 or D0, or earlier if required. When a NGT was in situ, EN was commenced continuously with the rate titrated against oral intake.

From D0, enteral feeds were changed to a hydrolysed peptide-based formula containing ~50% MCT to maximise EN delivery and tolerance (if not in use already). If the NGT dislodged during significant GI symptoms prior to engraftment, then in most instances it was not replaced until the patient had engrafted. The rate of EN was titrated to meet estimated energy requirements and GI tolerance. When EN provided < 50% of energy requirements for 4 consecutive days, PN was commenced and EN was adjusted according to tolerance. If NGT feeds were required pre and post the acute transplant period (before D0 and after D30), then a whole protein formula with energy density of 67kCal (280KJ) – 200kCal (840kJ)/100ml was used depending on the age, energy needs and GI tolerance.

Estimated energy requirements (EER) were calculated using either Nutrient Reference Values (NRV) for children under 3 years or the Schofield equation to measure basal metabolic rate (BMR) x 1.2-1.4 stress/activity factor for the pre- and post-acute HSCT period. From D0 to D30, energy requirements were reduced to NRV x 0.8-0.9 and Schofield BMR with no activity factor. This has been the practice at RCH based on clinical judgment and experience with reduced energy requirements also evidenced in the literature [18-20]. Protein requirements were estimated to meet the needs of critically ill children ranging from 1.5-3g/kg/d depending on age [21] and fluid targets were calculated using National Health and Medical Research Council guidelines [22].

Statistical analysis

Results have been expressed as frequencies and percentages for categorical variables and as means and medians for continuous variables. Formal statistical analyses were not completed in this cohort due to the multi variable analysis adjusting for differences that would be required. Therefore, detailed descriptive data has been presented only.

RESULTS

Between November 2017 - February 2019, 50 HSCT were performed with 48 patients (30 males, 18 females) recruited into the study. Of these, 2/48 underwent 2 transplants (therefore, counted as 2 separate HSCT patients) and 2/48 were excluded due to death prior to D30. The total number of transplants included is n=48. Of those transplanted, 26/48 was for a malignancy, 14/48 for an immunological condition, and 8/48 for a haematology disorder. No patients were transplanted for metabolic conditions during the time of the study. Of these transplants, 17/48 (35%) underwent a matched sibling transplant, 15/48 (31%) had a matched unrelated donor, 13/48 (27%) underwent a haplo-identical transplant and 3/48 (6%) had an unrelated cord donor transplant. Age at transplant ranged from 2 months to 17 years and median LOS was 58 days (range 36-438 days).

Of the 48 patients recruited, 43 (90%) had a NGT inserted and were considered for EN support using a standard nutritional assessment tool and HSCT feeding algorithm. Of these 43, 17 (40%) had a NGT placed prior to their BMT admission, 20 (47%) had an NGT placed on or around D0 and 6 (14%) had an NGT placed post engraftment. Five patients (10%) refused to have an NGT placed. These children were aged between 10-17 years.

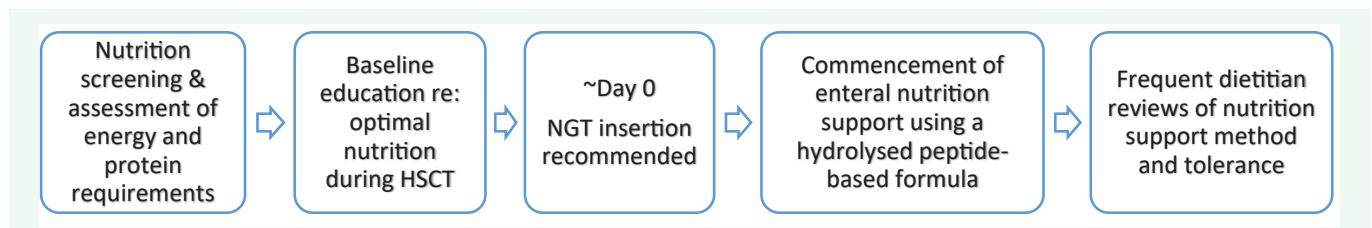


Figure 2 Standard nutrition support processes at RCH.

Table 2: Comparison of the adherence to the HSCT feeding algorithm by diagnostic groups, HSCT donor type, LOS, weight change and age.

Diagnostic groups	n=48	Followed algorithm	Algorithm not followed	Excluded as no NGT in situ	
Oncology	26	13 (53%)	5 (19%)	8 (31%)	
Immunology	14	9 (64%)	5 (36%)	0 (0%)	
Haematology	8	4 (50%)	1 (13%)	3 (38%)	
HSCT Donor Types	n=48	Followed algorithm	Algorithm not followed	Excluded as no NGT not in situ	
Matched Sibling	17	9 (53%)	3 (18%)	5 (29%)	
Matched Unrelated	15	9 (60%)	2 (13%)	4 (27%)	
Cord	3	1 (33%)	1 (33%)	1 (33%)	
Haplo identical	13	7 (54%)	5 (38%)	1 (8%)	
Length of stay, weight and age data comparisons	n=48	Followed algorithm (n=26)	Algorithm not followed (n=11)	Excluded as no NGT not in situ (n=11)	EN only (n=7)
Median LOS in days (range)		58 (36-438)	72 (41-97)	59 (38-94)	39 (36-63)
Median LOS in days (range) *outlier removed		53 (36-185)	72 (41-97)	59 (38-94)	39 (36-63)
Mean change in weight z score (D0 to D100)		0.17	-0.12	-0.1	0.1
Mean age		7.5	6.3	14	9
Sex					
Males		17	7	6	
Females		9	4	5	

All patients required some form of nutritional support during their transplant. Of these, 7/48 (15%) received EN only without PN. The five patients who did not have a NGT inserted received PN only. Of the 7 patients who received EN alone, all met greater than 40% of their EER via EN throughout their admission. A total of 43/48 (90%) patients received some EN during transplant with the average number of days on EN reported as 40 days.

Of the 43 patients enterally fed, 36 (84%) patients received a hydrolysed peptide-based formula at some point during their admission, 5 patients received a whole protein formula only and 2 patients were fed a free amino acid-based formula. Of the five who received a whole protein formula, four commenced EN post engraftment. The one patient who received a whole protein formula throughout the HSCT was established on this formula prior and bowels remained normal throughout the acute phase.

Of the patients who commenced EN, 30/43 (70%) patients required continuation of EN post discharge from acute HSCT admission. Fourteen (33%) had EN weaned prior to discharge, 2 required an extended stay for rehabilitation and 2 died during HSCT (post D30 so still included in study). At D100, 16 (37%) patients remained on EN and 3 (7%) remained on PN/EN.

PN was used in 41/48 (85%) of the patients. Twenty patients were commenced on PN based on the feeding algorithm decision pathway and 11 patients were commenced on PN despite this not being indicated by the feeding algorithm. Eleven patients required nutrition support via PN due to the missed opportunity for NGT placement before or during HSCT. For those receiving PN, average days on PN were 56 days, with one patient who was PN dependant for 237 days.

Of the 48 recruited patients, 11 (23%) were unable to follow the algorithm decision pathway as they did not have an NGT placed during the acute phase of HSCT. Of the remaining 37 patients, 26 (70%) followed the algorithm decision pathway as planned and 11 (30%) patients did not comply. Reasons for patients not following the algorithm decision pathway included pre-emptive commencement of PN without significant GI symptoms (n=6) and failure to grade feed due to GI toxicity concerns (clinician bias) despite not meeting objective criteria of the GI toxicity scale score (n=5).

The impact of the use of the HSCT feeding algorithm on LOS was investigated. This data was not normally distributed with a large skew, hence median (range) days are reported (refer

to Table 2). The group with the longest median LOS of 72 days was the group of patients who did not follow the algorithm. Those receiving EN only had the lowest median LOS of 39 days. Removing the outlier of 438 days LOS did not alter the reported outcome with LOS still being lower in the algorithm compliant group (53 days) compared to the non-compliant group (72 days).

The impact of the use of the HSCT feeding algorithm decision pathway on weight outcomes were reported as weight change in z scores between D0 and D100. The two groups that reported better weight outcomes during the HSCT were those who followed the algorithm and those who were fully EN fed without the use of PN (Table 2).

The association of the use of the algorithm with patient age was also investigated. The patient group that refused NGT placement were generally older with a mean age of 14 years. There was no apparent patient gender difference associated with the compliance of the algorithm (Table 2).

There were no observed differences between diagnostic groups or HSCT donor type and whether the algorithm was followed. Table 2 shows the proportion from each group whose nutrition management was compliant with the algorithm decision pathway. All immunology patients had an NGT placed at some stage during their HSCT and haematology patients had the highest proportion of children that refused to have an NGT placed. While all cord and haplo HSCT patients had an NGT placed at some point during their HSCT, 1 patient in each group didn't have an NGT in situ during the acute phase so had to be excluded.

DISCUSSION

The HSCT feeding algorithm decision pathway for children undergoing HSCT at RCH was implemented and evaluated. The algorithm was designed to guide objective decision making for nutrition support in this patient group. Effective use of the algorithm indicated improved patient outcomes with better weight outcomes and reduced LOS. Barriers to its use have been identified as patient age and clinician bias which resulted in missed opportunity for use of EN and inappropriate use of PN where not clinically indicated for some patients. This may have contributed to increased LOS and associated costs, yet no additional benefit to patient nutritional outcomes to warrant this.

Prior to implementation of the algorithm, a study conducted at RCH between 2014 -2017 collected data on 31 children undergoing HSCT. This study reported detrimental weight z scores (-0.23) and higher median LOS (67 days) which is consistent to that reported in our cohort of children who did not follow the algorithm compared to the group that did and further evidence of the efficacy of the algorithm.

The use of PN when not clinically indicated was the main barrier identified to algorithm compliance. This decision was based on clinician opinions and attitude towards EN at the time of patient review and not objective measures. This was most reported as pre-emptive concerns about worsening gastrointestinal symptoms and lack of confidence in grading up feeds. Information was collected on 48 patients over a 16-month period. Over this period the medical and dietetic treatment teams changed which may have contributed to inconsistent decision

making. This further supports the need for the use of an evidence-based standardised feeding algorithm decision pathway to guide the clinician on objective decisions for grading up of feeds rather than individual opinion.

Several patients in the cohort could not follow the algorithm as they refused to have an NGT placed and relied on PN support despite having a functional gut. Refusal of NGT placement in these children not only has cost implications due to the PN cost and increased LOS, but also a risk to patient outcomes including increased risk of infection, liver abnormalities and gastro-intestinal mucosal health [23]. Furthermore, EN has been associated with better survival, less acute GVHD and faster neutrophil recovery [2]. This group of children were on average 14 years of age. There is limited literature available that evaluates adolescent perceptions and attitudes towards NGT support during their oncology treatment. In a recent review, the perspectives of parent, patient and health professional were reported pre- and post-placement of an NGT in children <18 years. The main issues this review documented for pre-tube insertion included concerns about the child's physical appearance, invasiveness of the NGT and perceived tube discomfort. Post-NGT insertion the reported perceptions were more positive and included opportunity for weight gain, better nutritional intake, less worry/pressure to eat. Essentially, the parent and patient negative views changed once NGT was inserted and the benefits of NGT feeding were realised [24]. Increased support and education with patients/families is recommended to ensure realistic expectations and positive patient experience and outcomes.

A Children's Oncology Group (COG) study examined the nutrition support standards of practice at 125 member sites and showed that enteral feeding was not consistently offered as the first method of nutrition support to patients. Variability in the use of enteral and parental nutrition was dependent on clinician, nurse and dietitian viewpoint and historical practice rather than following best practice guidelines [25].

Effective decision making and acceptance of NGT placement can be facilitated by tools such as a HSCT feeding algorithm to allow unbiased and balanced information provision to guide the best clinical care for the patient. Education and communication for the oncology team around these standardised algorithms may help facilitate objective decisions around NGT support. In addition, often these practices need to be initiated early in a child's treatment as the success of EN during HSCT can be dependent on a child's nutrition support experiences throughout their treatment [6].

Due to well documented gaps in implementing evidence-based feeding practices, nutrition support algorithms have been developed to ensure patients receive nutrition care based on the available scientific evidence, with the aim to improve the patient's nutritional outcomes. These algorithms provide specific steps in the nutrition support decision making process based on patient condition and objective assessment [26]. While nutrition support algorithms to guide feeding in oncology patients have been shown to reduce days on PN and facilitate enteral feeding, the practices require ongoing reinforcement and education to clinicians and support from the multidisciplinary team, especially dietitians, nurses and physicians [6]. A recommendation for ongoing

compliance with the HSCT feeding algorithm includes frequent education sessions for rotating medical teams and nurses.

Ninety percent of patients received EN at some stage during their HSCT. This is a positive outcome as even trophic feeds have been shown to maintain intestinal function and integrity, reduce potential translocation, reduce HSCT complication rates, promote better survival, reduce risk of GVHD, facilitate faster neutrophil recovery and reduce hospital LOS [2,5,9,23]. It was also observed that patients who didn't require any PN or who followed the algorithm had the shortest LOS, and conversely those who didn't follow the algorithm or refused to have an NGT had the longest LOS. A contributing factor to this finding is because discharge could still be facilitated with home EN support if oral intake was still inadequate, which was not possible with patients on PN despite being medically ready for discharge.

There were no apparent differences in adherence to the HSCT feeding algorithm by comparing diagnosis for HSCT, donor type and sex. The algorithm has been designed using objective criteria of GI clinical tolerance symptoms independent of diagnosis, HSCT donor type and age, and hence has the advantage that it can be used across all types of HSCT condition regimens [27]. Barriers to effective use of the algorithm have been discussed and fall into two main categories, firstly being no NGT placement to provide EN and secondly inappropriate use of PN. Opportunities to strengthen relationships with key stakeholders such as the PN team and gastroenterology to help advocate for algorithm compliance may help to overcome future barriers to its use in addition to frequent education within the oncology multi-disciplinary team.

Limitations to the study included the potential accuracy of multiple clinicians measuring, reporting, documenting, and interpreting the gastrointestinal symptoms and accurate recording and reporting of oral intake. The algorithm suggests a criterion of greater than 50% of EER from EN and oral intake over 4 days to guide decisions regarding nutritional management. Although this may be difficult to estimate daily, all patients at some stage for a period of greater than 4 days were estimated to have less than 20% of their EER from EN or oral intake. Strengths to the study included a consistent team of Dietitian's for robust data collection and a prospective study design. The use of an electronic medical record was also a major advantage.

CONCLUSION

Effective use of the HSCT feeding algorithm decision pathway indicated improved patient outcomes for children undergoing HSCT, with better weight outcomes and reduced LOS. Barriers to its use were identified. Recommendations to improve the efficacy of the feeding algorithm decision pathway include regular education and input to the oncology medical teams to better understand objective thresholds for EN and PN commencement.

STATEMENT OF AUTHORSHIP

J. Bartle conceptualised and designed the study, contributed to data collection, analysis, and interpretation, and drafted the manuscript. N. T. Whitehead and E. Alexander contributed to acquisition, collection, analysis, and interpretation of data. H. Gilbertson contributed to design and interpretation of data

and drafting of manuscript. All authors critically revised the manuscript, agree to be fully accountable for accuracy of the work and read and approved manuscript.

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CLINICAL RELEVANCE STATEMENT

The evaluation of a nutrition feeding algorithm for children and adolescents undergoing HSCT is clinically relevant as can assist in guiding clinicians to implement nutrition support to better understand indicator thresholds for the commencement and progression of enteral and parenteral nutrition to help provide optimal nutrition support during HSCT.

REFERENCES

1. El-Ghammaz AMS, Matoug RB, Elzimaity M, Mostafa N. Nutritional status of allogeneic hematopoietic stem cell transplantation recipients: influencing risk factors and impact on survival. *Support Care Cancer*. 2017; 25: 3085-3093.
2. Baumgartner A, Bargetzi M, Bargetzi A, Noemi Zueger, Micheal Medinger, Jakob Passweg, et al. Nutritional support practices in hematopoietic stem cell transplantation centers: A nationwide comparison. *Nutrition*. 2017; 35: 43-50.
3. Espinoza M, Perelli J, Olmos R, Bertin P, Jara V, Ramirez P. Nutritional assessment as predictor of complications after hematopoietic stem cell transplantation. *Rev Bras Hematol Hemoter*. 2016; 38: 7-14.
4. Andersen S, Kennedy G, Banks M. A randomised controlled comparison of enteral versus parenteral nutritional support post allogeneic haematopoietic cell transplantation. *Clin Nutr ESPEN*. 2015; 10: e102-e106.
5. Azarnoush S, Bruno B, Beghin L, D Guimber, B Nelken, I Yakoub-Agha, et al. Enteral nutrition: a first option for nutritional support of children following allo-SCT? *Bone Marrow Transplant*. 2012; 47: 1191.
6. Steele C, Salazar A, Rypkema L. Utilization of a nutrition support algorithm reduces unnecessary parenteral nutrition use in pediatric oncology inpatients. *J Acad Nutr Diet*. 2016; 116: 1235-1238.
7. Cohen J, Maurice L. Adequacy of nutritional support in pediatric blood and marrow transplantation. *J Pediatr Oncol Nurs*. 2010; 27: 40-47.
8. Mantegazza C, Landy N, Zuccotti G, Köglmeier J. Indications and complications of inpatient parenteral nutrition prescribed to children in a large tertiary referral hospital. *Ital J Pediatr*. 2018; 44: 66.
9. Bicakli DH, Yilmaz MC, Aksoylar S, Kantar M, Cetingul N, Kansoy S. Enteral nutrition is feasible in pediatric stem cell transplantation patients. *Pediatr Blood Cancer*. 2012; 59: 1327-1329.
10. Seguy D, Berthon C, Micol J-B, Stéphane Darré, Jean-Hugues Dalle, Sylvain Neuville, et al. Enteral feeding and early outcomes of patients undergoing allogeneic stem cell transplantation following myeloablative conditioning. *Transplantation*. 2006; 82: 835-839.
11. Hopman G, Pena E, Le Cessie S, Van Weel M, Vossen J, Mearin M. Tube feeding and bone marrow transplantation. *Medical and Pediatric Oncology*; 2003; 40: 375-379.
12. Garófolo A. Enteral nutrition during bone marrow transplantation in patients with pediatric cancer: a prospective cohort study. *Sao Paulo Med J*. 2012; 130: 159-166.
13. Health UDo, Services H. Common Terminology Criteria for Adverse Events (CTCAE) v5.0. Published Nov. 27, 2017. In: 2018.

14. Seguy D, Duhamel A, Rejeb MB, Emmanuel Gomez, Nicolas Danel Buhl, Bénédicte Bruno, et al. Better outcome of patients undergoing enteral tube feeding after myeloablative conditioning for allogeneic stem cell transplantation. *Transplantation*. 2012; 94: 287-294.
15. Gonzales F, Bruno B, Fuentes MA, E De Berranger, D Guimber, H Behal, et al. Better early outcome with enteral rather than parenteral nutrition in children undergoing MAC allo-SCT. *Clin Nutr*. 2018; 37: 2113-2121.
16. D'Antiga L, Goulet O. Intestinal failure in children: the European view. *J Pediatr Gastroenterol Nutr*. 2013; 56: 118-126.
17. Lapillonne A, Matar M, Adleff A, Chbihi M, Kermorvant-Duchemin E, Campeotto F. Use of extensively hydrolysed formula for refeeding neonates postnecrotising enterocolitis: a nationwide survey-based, cross-sectional study. *BMJ open*. 2016; 6: e008613.
18. Ringwald-Smith K, Heslop H, Krance R, PW Mackert, ML Hancock, LM Stricklin, et al. Energy expenditure in children undergoing hematopoietic stem cell transplantation. *Bone Marrow Transplant*. 2002; 30: 125.
19. Sharma TS, Bechard LJ, Feldman HA, Robert Venick, Kathleen Gura, Catherine M Gordon, et al. Effect of titrated parenteral nutrition on body composition after allogeneic hematopoietic stem cell transplantation in children: a double-blind, randomized, multicenter trial. *Am J Clin Nutr*. 2011; 95: 342-351.
20. Duro D, Bechard LJ, Feldman HA, Arkady Klykov, Alice O'Leary, Eva C Guinan, et al. Weekly measurements accurately represent trends in resting energy expenditure in children undergoing hematopoietic stem cell transplantation. *JPEN J Parenter Enteral Nutr*. 2008; 32: 427-432.
21. Mehta NM, Compher C, Directors ABo. ASPEN clinical guidelines: nutrition support of the critically ill child. *JPEN J Parenter Enteral Nutr*. 2009; 33: 260-276.
22. Australian-Government. Nutrient reference values for Australia and New Zealand including recommended dietary intakes. In: Commonwealth of Australia Canberra; 2006.
23. Ladas EJ, Sacks N, Meacham L, Dave Henry, Lori Enriquez, Genevieve Lowry, et al. A multidisciplinary review of nutrition considerations in the pediatric oncology population: a perspective from children's oncology group. *Nutr Clin Pract*. 2005; 20: 377-393.
24. Cohen J, Wakefield CE, Tapsell LC, Walton K, Cohn RJ. Parent, patient and health professional perspectives regarding enteral nutrition in paediatric oncology. *Nutr Diet*. 2017; 74: 476-487.
25. Ladas EJ, Sacks N, Brophy P, Rogers PC. Standards of nutritional care in pediatric oncology: results from a nationwide survey on the standards of practice in pediatric oncology. A Children's Oncology Group study. *Pediatr Blood Cancer*. 2006; 46: 339-344.
26. Kiss CM, Byham-Gray L, Denmark R, Loetscher R, Brody RA. The impact of implementation of a nutrition support algorithm on nutrition care outcomes in an intensive care unit. *Nutr Clin Pract*. 2012; 27: 793-801.
27. Boutaina Zemrani, Jason K Yap, Ben Van Dort, Victoria Evans, Jodie Bartle, Danielle Shandley, et al. Nutritional challenges in children with primary immunodeficiencies undergoing hematopoietic stem cell transplant. *Clin Nutr*. 2020; 39: 2832-2841.

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